Volume 3 APRIL, 1924 Number 4

JOURNAL

OF THE

AMERICAN WELDING SOCIETY

Published Monthly by the American Welding Society
33 West Thirty-ninth Street, New York

American Welding Society

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JOURNAL

OF THE

AMERICAN WELDING SOCIETY

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33 West Thirty-ninth Street, New York.

Subscription $10.00 per year to United States. $11.00 to Canada. Libraries $5.00.
Back numbers, per copy: Members, $0.50; Non members, $1.00.

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AMERICAN WELDING SOCIETY
ESTABLISHED 1919
JOURNAL

Volume 3 April, 1924 Number 4

Tentative Program
Annual Meeting

of the

AMERICAN WELDING SOCIETY

33 West 39th Street, New York, N. Y.

April 23, 24, 25 *and* 26, 1924.

All Sessions Start Promptly as Scheduled.

WEDNESDAY, APRIL 23, 1924

Morning

Resistance Welding Committee, Hermann Lemp, Chairman.
9.30 a. m. to 12, 10th floor.

Completion of summary setting forth the present state of the art. Consideration of future work of committee. Election of officers.

Afternoon

Electric Arc Welding Committee, H. M. Hobart, Chairman.
2.00 p. m., 10th floor.

Plans for completing elaborate series of investigations started during the War, fabrication by welding in structural work, welding of non-ferrous metals and the use of fluxes and slags in arc welding.

Evening

Smoker, American Welding Society.
8.00 p. m., 5th floor.

Note: This session is a new feature in connection with the Annual Meeting of the Society. It is planned to make this a "social evening." Smokes and cider will be distributed. A motion picture on the "Applications of Welding in the Plant of the E. G. Budd Manufacturing Company" will be shown by Mr. Jos. W. Meadowcroft, Superintendent of Welding. An opportunity will be provided for an informal discussion of the affairs of the Society. The Master of Ceremonies will be Mr. C. J. Holslag of the Electric Arc Cutting & Welding Company. The program of the evening will be entertaining and instructive.

THURSDAY, APRIL 24, 1924

Morning

Business Session of American Welding Society

9.30 a. m. to 12, 5th floor.

Program

1. President's Report of Year's Activities.
2. Reports from (a) Finance Committee.
   (b) Meetings and Papers Committee.
   (c) Research Department (American Bureau of Welding).
   (d) Report of Tellers Committee on Election of Officers.
   (e) Introduction of New President.

Afternoon

Board of Directors, American Welding Society.

(Including retiring and new members).

2.00 p. m., 10th floor.

Program

1. Review of progress during past year.
2. Introduction of new President.
3. Plans for coming year.
4. Appointment of Committees (a) Executive.
   (b) Membership.
   (c) Finance.
   (d) Meetings and Papers.
   (e) Revision of By-laws.

1.45 p. m., Inspection Trip to Brooklyn Navy Yard.

Through the courtesy of Capt. S. V. Graham an inspection trip has been arranged to the New York Navy Yard. The trip will include an inspection of the Oxy-Hydrogen and Acetylene Generating Plants and thence to the shipways where the battleships "Indiana" and "South Dakota" are being cut into scrap. The inspection trip will also include visits to the plate shop and machine shop and other departments in which gas and electric welding are being used. It is planned to secure permission to go on board of the "Colorado" or the "Indiana." The foundry will be open for inspection and members will have an opportunity to see the casting of water pipe by the centrifugal process.

Evening

The Third Annual Dinner of the American Welding Society.

7.00 p. m., Park Avenue Hotel.

Good talent and plenty to eat at the usual price of $5 per person. Four special speakers are being secured. Reservations should be made at once.

FRIDAY, APRIL 25, 1924

Morning

American Bureau of Welding

9.30 a. m. to 12, 11th floor.

Program

1. Progress Reports by Research Committee Chairmen.
2. Election of Officers.
3. Discussion of Policies.
4. Discharge of Committees that have completed their work.
5. Appointment of new Committees.

Afternoon

Gas Welding Committee, S. W. Miller, Chairman

1.30 p. m., 11th floor.

Completion of Summary on Pipe Welding. Program for future activities.

Evening

Technical Session of the American Welding Society

8.00 p. m., 5th floor.

Program

1. Flexibility Versus Rigidity in the Design of Welds.
   a. Carbon Arc Welding, J. C. Lincoln.
   b. Gas Welding, S. W. Miller.
   c. Metal Arc Welding, C. J. Holslag.
   d. Resistance Welding, H. A. Woofter.
   e. Thermit Welding, J. H. Deppeler.
2. Welding in Railroad Shops, A. G. Pack, Chief Inspector, Bureau of Locomotive and Boiler Inspection, Interstate Commerce Commission.

SATURDAY, APRIL 26, 1924

Specifications for Steel to be Welded Committee,
W. J. Beck, Chairman

9.30 a. m., 10th floor.

Plans for future work of Committee.

KANSAS CITY SECTION ORGANIZED

The tenth local section of the American Welding Society was formally organized in Kansas City on April 1. Sixty-three people interested in welding were present. The organization meeting was successful and temporary officers were elected. The first regular meeting will be held on the first Tuesday in May, at which time it is hoped to have some national officer present. The prospects for a large membership in this section are very good. The temporary officers are:

A. M. Griffin, chairman, consulting engineer, Columbia Steel Tank Co.

Frank Luff, vice-chairman, Kansas City Bolt & Nut Co.

W. S. Klein, secretary-treasurer, Prof. Klein Welding Co.

I. W. Wilkinson, chairman, membership committee, Quick Service Company.

W. J. Thomas, chairman, relations committee, district manager, Purox Co.

FINANCIAL STATEMENT

REPORT OF AUDITOR

William J. Struss & Co., Certified Public Accountants, 130 William Street, New York.

April 7, 1924.

American Welding Society,
29 West 39th Street, New York City.

Dear Sirs:

We have examined the Cash records for the twelve months ended March 31, 1924.

Attached hereto is a Statement of Receipts and Disbursements for year ended March 31, 1924.

We find that these records are verified by the reports of the Bankers Trust Co. and that the cheques for disbursements are as indicated on the Cash records.

The items "starred," Dues, etc., $102.50, and Administration Expenses A. B. of W., $400.00, were not passed through the bank.

Yours very truly,
WM. J. STRUSS & CO.,
Certified Public Accountants.

Statement of Receipts and Disbursements for the Year Ended

March 31, 1924

Receipts

Dues	$9,984.43	
Dues	102.50*	
Journal Advertising	8,750.30	
Journal Subscriptions	419.48	
Bound Volumes	220.90	
Bulletins	119.60	
Reprints	98.00	
Refund on Cuts	73.43	
Pressure Vessel Reports	543.53	
Committee Refunds (Pressure Vessel-Welded Joints)	294.84	
Welding Encyclopaedias	54.20	
Society Emblems	17.45	
Annual and Fall Dinners	614.50	
Refund Installing Bookkeeping System	60.00	
†Administration Expenses A. B. of W	1,600.00	
†Administration Expenses A. B. of W	400.00*	
Miscellaneous	61.87	
Bank Interest	57.64	
Total Receipts		$23,472.67
Balance April 1, 1923		1,596.64
		$25,069.31

Disbursements

Salaries	$4,920.00	
Editorial Services	1,800.00	
Printing Journal	3,945.28	
Binding Journal	127.59	
Printing Index (1922 and 1923)	64.00	
Reprints	110.00	
Rent	1,152.00	
Telephone and Telegraph	286.90	
Printing and Stationery	497.56	
Printing (Promotion)	305.80	
Postage	616.30	
Equipment	140.28	
Welding Encyclopaedia	23.00	
Annual and Fall Meetings	358.32	
Annual and Fall Dinners	584.75	
New York Section Expenses	290.40	
Refund Dues	10.00	
Refund Advertising	88.20	
Auditing and Installing Bookkeeping System	181.65	
Administration Expenses of A. B. of W	1,600.00	
Administration Expenses of A. B. of W	400.00*	
Miscellaneous	270.96	
Refunds to Sections	3,327.50	
Refunds to Sections	102.50*	
Total Disbursements		$21,202.99
Balance March 31, 1924		3,866.32
		$25,069.31

†*Note:* An arrangement was made with National Research Council whereby the welding industry paid the Council $2,000 for the administrative expenses of the Bureau. The funds were contributed by the Welded Rail Joint Committee, Union Carbide and Carbon Research Laboratories, Westinghouse Elec. and Mfg. Co., Lincoln Electric Co., Metal and Thermit Corporation, Alexander Milburn Co., Burke Electric Co., Air Reduction Sales Co. The American Welding Society acted as Treasurer for the funds.

Estimated Budget, Year 1924

INCOME		EXPENSE	
Advertising (signed contracts)	$8,919.20	Salaries	$4,920.00
Journal subscriptions	600.00	Editorial services	1,800.00
Bound volumes	400.00	Printing journal	4,200.00
Bulletins	100.00	Binding journals and printing index	150.00
Membership dues	12,150.00*	Room rental	1,152.00
	$22,169.20	Stationery and printing	1,000.00
		Telephone and telegraph	250.00
		Postage	500.00
		Meetings	500.00
		Equipment	200.00
		Miscellaneous	150.00
		Section refund (N. Y. Section excluded)	3,530.00
		New York Section expenses	450.00
		Promotion — pamphlets, membership letterheads, etc.	500.00
			$19,302.00

*This figure is based on dues from present members. $2,920 of this is in delinquent dues, some of which will probably not be collected but will be replaced by new members.

FINANCES

The report of the finance committee, given elsewhere in the JOURNAL, tells its own story. It is very interesting, however, to compare it with the financial statements of April, 1922 and 1923. The total income for the fiscal year ending April 1, 1922, was $12,683.74. In 1923 this income was $18,439.68. The statement given for 1924 shows that the total income, after deducting the administrative expenses of the Bureau of Welding was $23,069.31. These figures show clearly that the American Welding Society is growing and is needed and wanted by the welding industry. It is an organization that everyone who is interested in welding must belong to for their own good and advancement.

It is also interesting to analyze in detail where this money came from and how it was spent. Less than one half of the total funds received by the Society came from membership dues. Of this amount, $3,000 came from dues from Class C and D members. It will, therefore, be seen that the welder members actually received the returns from an expenditure of over seven times the amount that they contributed. We would regard ourselves as highly fortunate were we able to make financial investments whereby we received an annual return of 700 per cent.

INSPECTION TRIP

An indicated in the program of the annual meeting, an inspection trip has been arranged for 2 P. M., Thursday, April 24, to the Brooklyn Navy Yard. This trip was made possible through the courtesy of Captain Stephen V. Graham of the Brooklyn Navy Yard. Captain Graham will arrange to receive the party at the Cumberland Street gate and guards will escort the party in small groups to the oxy-hydrogen and acetylene generating plants. The plant is capable of producing 10,000 cu. ft. of oxygen per 24-hr. day. The party will then proceed to the shipways, where the battleships "Indiana" and "South Dakota" are being cut into scrap at the rate of 1,000 tons per week under the direction of Lieut. J. G. Shaw of the U. S. Navy. The two vessels represent about 18,000 tons of steel.

The power of the cutting torch is illustrated in a remarkable way in this scrapping operation. Twelve cutters or burners working on each vessel (24 in all) are demolishing the work of 700 men who were employed on each vessel at the height of construction work.

The battleships are cut into shipping sizes, approximately 8 ft. x 20 to 30 ft. The inspection trip will include the plate shop, machine shop and other departments, in which some gas and electric welding will be going on. Captain Graham will arrange for permission to go on board the Colorado or the Indiana, if any of the visitors desire. The foundry will be open for inspection and members will have an opportunity to see the casting of water pipe by the centrifugal process.

If sufficient members sign up in advance, arrangements will probably be made for transporting the entire party from the Engineering Societies Building to the Navy Yard. Inquiry should be made from the Secretary at the time of the annual meeting.

TECHNICAL PAPERS

The American Welding Society is very much in need of satisfactory technical papers for publication in its Journal. We are regarded as the most authentic source for the dissemination of information on welding and we can only keep this reputation through the cooperation of all our members in furnishing suitable papers.

The meetings and papers committee desire papers particularly on any of the following subjects:

1. Description of new applications of welding.
2. Description of application to production work including full information as to preparation, technique, use of jigs and fixtures.
3. Results of any research investigations and tests.

REPORT OF MEETINGS AND PAPERS COMMITTEE, AMERICAN WELDING SOCIETY

April 11, 1924.

As the present chairman has only been in office a few weeks he has but little knowledge of the work of the committee during the greater part of the last fiscal year. Fortunately, Mr. Spraragen has offered to supply the necessary information, and this report should therefore be considered as mostly his work.

Aid Rendered to Sections:

Last fall the committee was called upon to render such assistance as it

could in helping certain sections arrange programs for their monthly meetings and to secure suitable speakers. It was felt necessary to get in touch with members of each local section in order to ascertain local problems and needs. A questionnaire was sent out and valuable data secured as to the kind of papers that would interest local sections. The replies were quite varied. However, in a number of instances it was possible to put the local section officers in touch with suitable speakers.

National Meetings:

There are two general meetings of the Society, the fall meeting in October and the annual meeting in April. The fall meeting of 1923 was held in Pittsburgh. A comprehensive review of what transpired was published in the November, 1923, issue of the JOURNAL. The outstanding feature of the meeting was the large attendance of out-of-town members. For the first time the meetings and papers committee took it upon itself to prepare a technical paper on the "Industrial Applications of Welding and Cutting and Their Possibilities." This paper was received with great interest and recopied by a number of important technical journals. It brought out strikingly the progress that welding has made during the past few years and indicated to the progressive executive the desirability of thoroughly acquainting himself with the economic advantages which might accrue to his company from the use of welding in his plant. As usual, the research sessions were one of the prominent features of the Fall program. Fortunately for the American Welding Society, its far-sighted founders realized the importance of research work and made it a vital part of the Society. Those who attended the Pittsburgh meeting will have pleasant remembrances of the dinner and the unusual entertainment features as well as the inspection trip to the Westinghouse Works and to the Carnegie Steel Plant at Homestead.

The program for the annual meeting of the Society was published in the March issue of the Journal. An unusual feature of this program is a smoker. It is hoped that the members of the Society will help make this session a success in order that in the future it may be made a regular part of the annual program. An inspection trip has been arranged through the Brooklyn Navy Yard, which will afford our members an opportunity to see the applications of cutting on a very large scale. The other features of the program are about the same as they were last year.

Publications:

The Society can look with great pride upon its official organ the Journal of the American Welding Society. The bound volume for 1923 forms an attractive, good sized book which contains information worth many thousands of dollars to users of welding. There are altogether 792 pages in this bound volume exclusive of covers. This compares very favorably with the 600 printed pages in the 1922 bound volume.

Approximately 20 per cent of these pages are either "standing form pages" or advertising. In order to make the Journal more useful to the members, an index of subjects and authors for both the 1922 and 1923 volumes was printed and distributed. Extra copies were run off to be used by the Membership Committee in its work. One of the outstanding features of the Journal is the large number of reports of the Research Department of the Society, the American Bureau of Welding. In addition to the technical papers, there are appropriate sections devoted to editorials, news items of the Society, progress reports of committees, employment service bulletin, question and answer column, section activities, new members and current welding literature. One of the satisfactory features of the Journal is the revenue involved. For two years in succession the cost has been kept within the budget allowed for it. The total receipts from advertising, subscription and refunds on cuts amounted to $8,780.19, as against a total expenditure of $5,395.80, leaving a profit for the year of $3,384.39.

The creditable showing places the responsibility on the Meetings and Papers Committee of "delivering the goods," thereby rendering it possible to maintain this source of revenue for the Society. We must help the Membership Committee in its campaign to increase the number of members, as in this way our circulation is increased and hence greater returns accrue to our advertisers. We must also make the character of the Journal such that no one who is interested in welding can afford to do without it.

Membership Directory:

At one of the recent meetings of the Meetings and Papers Committee it was unanimously agreed to recommend to the Board of Directors the publication of a Membership Directory as the August, 1924, issue of the Journal. Some doubts were expressed as to the way this proposal would be received by our advertisers, but we are pleased to report that all of them have consented to this arrangement and a number have indicated their willingness to take out increased advertising space. This arrangement promises not only to save some money but actually to bring a profit to the treasury of the Society.

Conclusions:

The Meetings and Papers Committee wishes at this time to express its appreciation of the hard work of its former chairman, Mr. A. G. Oehler, who resigned from the office during the latter part of 1923, although he continues to serve as a member of the committee.

A fertile field for increased activities of the committee is in the help it might render to local sections in arranging their monthly programs. This can only be done if all members of the Society who can present papers and addresses before local sections will volunteer to do so. There are many members who have devoted years of study and effort on a particular phase of the welding field. Their experience and knowledge would be of assistance and an inspiration to others.

Respectfully submitted,
Meetings and Papers Committee,
K. H. Condit, Chairman.

American Bureau of Welding Annual Report: Outstanding Features of Progress, April, 1923, to April, 1924

General

The principal activities during the past year have been the finishing up of the work started during the previous years. No new committees have been organized, although one is contemplated on "Applications of Welding in the Structural Steel Field." The use of welding is extending daily. Applications have nearly trebled during the last few years. Scratching the surface of scientific investigations has made it possible to overcome apparently insurmountable obstacles. The American Bureau of Welding is doing its share in helping to bring about the extension of the use of welding, in solving difficult problems arising in the industry and in disseminating needed information. The Bureau is now recognized as the best source of authentic welding information in the world. Requests for assistance come not only from this country but also from abroad.

Publications

The medium through which the Bureau disseminates its information is the Journal of the American Welding Society. Important reports are also reprinted by the Society in bulletin form.

In one instance, namely the report of the sub-committee of the Electric Arc Welding Committee on "Applications of Arc Welding to Ship Construction," it was not possible to use the Journal as the medium of publication. The length, numerous illustrations and tabular matter rendered the publication of this report so costly that it was necessary to secure the assistance of one of the leading papers in the shipbuilding field, namely, "Marine Engineering." Through the courtesy of this publication the report was published as a serial and later reprinted in bulletin form, and enough copies made available for the entire membership of the Society.

Administration

The American Bureau of Welding acts as the welding research department for the American Welding Society and the Division of Engineering, National Research Council. It has in its membership representatives from some twenty scientific and technical organizations interested in welding. The Bureau acts under its own by-laws, which are subject both to the by-laws of the American Welding Society and the Division of Engineering, National Research Council. Office facilities are furnished by the American Welding Society, although in one or two instances where committees have sufficient funds the Society has been

reimbursed for an appropriate portion of this expense.

Technical Work

Technical Information Service

Several hundred requests for information have been satisfactorily answered during the past year. Most of these are referred to recognized experts on the particular subject. Sometimes these replies involve a thorough sifting of all available knowledge. For example, a request came to the Bureau for reliable information on the welding of manganese frogs, crossings and steel points from the Haagsche Tramweg Maatschappig, Gravenhage, New Netherlands. Information furnished included replies received from sixteen experts and occupied eighteen printed pages in the Journal of the American Welding Society.

Research Committees

The most important report published during the past year is Bulletin No. 5 of the American Welding Society on "Investigation of Welded Pressure Vessels." This report of 152 printed pages was prepared in cooperation with the Bureau of Standards and the American Society of Mechanical Engineers and consists of test results obtained from the destructive tests of some forty-five welded pressure vessels, an interpretation of these test results, and also some definite recommendations to the Boiler Code Committee of the A. S. M. E. The object of this investigation was to secure reliable information which would enable the Boiler Code Committee of the A. S. M. E. to draw up satisfactory rules governing the use of welding in such construction, and testing of the finished product. Eight manufacturers cooperated by furnishing the necessary funds. The testing was done at the Bureau of Standards, under the auspices of an appropriate committee. As a side issue of the above, the Committee has been instrumental in bringing about satisfactory changes in the regulations governing the use of welding in the construction of fuel oil storage tanks in the City of New York. The cost of this investigation, including materials, but not services of staff engineers, is estimated at $15,000. Several of those who contributed toward this fund have stated that any one of the several important conclusions drawn was worth many times the entire cost of the investigation.

Active progress continues by the Committee on Welded Rail Joints. It is estimated that improvements in methods would undoubtedly result in increasing the life of the joint at least 25 per cent, which would in turn result in an annual saving to the street railways of $15,000,000. A preliminary series of tests to determine the present state of the art of making rail joints is well under way and a second progress report giving the results of these tests has been published. The work of this Committee has involved cooperation on a very large scale. The Committee itself is the largest affiliated with the Bureau, having over fifty representatives from the larger street railways, joint manufacturers, testing laboratories and manufacturers of welding equipment. Actual cash funds secured by the Committee have been over $23,000. Services, materials for test specimens, and laboratory facilities amount to approximately three times the cash contribution.

Other committees which have completed their work during the past year are the Storage Tank Committee, which has drawn up specifications for the construction of large oil storage tanks, and the Committee on Training of Welding Operators, which has completed satisfactory courses for the training of oxy-acetylene and electric welders. These two training reports have been prepared largely through the assistance of the Federal Board of Vocational Education and have now been published and made available to the industry.

A comprehensive report was prepared under the auspices of the Electric Arc Welding Committee on the "Applications of Arc Welding to Ship Construction." Another subcommittee of this Committee has prepared a digest of available information on the arc welding of non-ferrous metals. This report has been published in the March issue of the Journal. A series of investigations has been outlined to secure information that is lacking and to settle disputed points.

Aims

As there are doubtless many members of the Society who are not very familiar with the aims and purposes of the American Bureau of Welding, a brief statement of these aims is given herewith as a part of the Annual report.

First, To bring to bear on the solution of welding problems the latest scientific knowledge and the scientific method of attack. To this end the cooperation of all interested scientific

and engineering organization has been enlisted.

Second, To provide an organization whose reports and pronouncements will be accepted the world over as sound and absolutely free from commercial bias. To this end the Bureau has a governing body separate from that of the Society. However, it should be remembered that the Bureau is primarily the child of the Society and largely dependent upon the members of the Society for its support.

Thus far much has been accomplished without any appreciable financial support from the Society as an organization; but you should realize that it is your Bureau and that if it is to fulfill its purpose in any comprehensive manner it must have the full sympathetic cooperation and material assistance from every member of the Society. You must also realize that the standing and prestige of the Society throughout the world is largely dependent upon the work of the Bureau. We are all proud of that work, but let us give material expression to our pride.

Conclusions

Active progress continues by a number of the other committees, although such progress is greatly retarded by the lack of paid technical assistance. Members of committees are so busy that it is difficult to get them to give the necessary time for Committee work. It is planned to discharge several of the research committees who have completed their work and to concentrate attention on unfinished work before undertaking new projects.

C. A. ADAMS,
Director.

New Members for the Months of January, February and March, 1924

BOSTON

Walter J. Croft, Jr. Foreman of Machine Shop, Thomas G. Plant Co., 89 Bickford St., Jamaica Plain, Mass. C

H. J. Lemp, 69 St. Botolph St., Boston, Mass. C

J. W. Morrissey, Salesman, P. F. McDonald & Co., 17 King Terminal, Boston, 27, Mass. C

L. F. Brooks, 27 Fuller St., Lynn, Mass. ..... D

G. E. Hill, Keene, N. H. ..... D

CHICAGO

E. W. Lloyd, General Contract Agent, Commonwealth Edison Co., 72 West Adams St., Chicago, Ill. ..... A

E. R. Chinberg, Supervisor of Electrical Equipment, Chicago, Rock Island & Pacific R. R., El Reno, Okla. ..... D

Emil Raepke, 2304 West 35th Place, Chicago, Ill. ..... D

NEW YORK

Y. Adzuma, Mechanical Engineer South Manchuria Railway Co., 111 Broadway, New York City ... B

J. Barton Nealey, President American Welding & Machine Wks., Inc., 66-68 Marshall St., Newark, N. J. ..... B

J. Von der Heyde, Production Mngr. De La Vergne Machine Co., Foot East 138th St., New York ..... B

N. Hajinian, 200 East 27th St., New York ..... D

Gardner P. Herald, Elec. Welder, 445 Mountain Ave., Westfield, N. J. ..... D

A. R. Quirk, Welding Foreman, Astoria Welding Co., 288 4th Ave., Long Island City ..... D

NORTHERN NEW YORK

Geo. B. Histed, Asst. Supt., General Construction Dept., Rochester Gas & Elec. Corp., Rochester, N. Y. ..... B

Wm. P. Madden, Commercial Engr., Industrial Dept., General Electric Co., Schenectady ... C

F. M. Womeldorff, Acetylene Welder, Ireland Mach. Fndry Co., Norwich, N. Y. C

PHILADELPHIA

James G. Christhilf, Student, Mechanical Engineering, The Magneto & Machine Co., 1031 Cathedral St., Baltimore, Md. C

PITTSBURGH

T. B. Ambrose, Salesman, The Imperial Brass Mfg. Co., 1103 House Bldg., Pittsburgh, Pa. ..... D

N. W. Watkins, Salesman, The Imperial Brass Mfg. Co., 1103 House Bldg., Pittsburgh, Pa.....D

SAN FRANCISCO

David L. Calder, Supt., Calif. Steel Products Co., 452 Bay St., San Francisco, Cal.....B
H. H. Plummer, Mngr., Coast Dept., Commercial Acetylene Supply Co., San Francisco, Cal..B
Norman R. Ennis, Welder, Southern Pacific West Oakland Shipyard, 1049 57th St., Oakland, Cal. C
R. E. Frickey, Proprietor, Welding Service & Supply Co., 559 Howard St., San Francisco, Cal..D
J. F. Kordic, Welder, Electric Steel Foundry, 24th & York Sts., Portland, Ore.....D
Robt. W. McClelland, Welder, Union Oil Co., Santa Fe Springs, Cal. .....D

SOCIETY

Walker Lewis, American Rolling Mill Co., Middletown, Ohio.....B
W. C. Sprau, Mech. Engr. and Treasurer, Barnes Wire Fence Co., 1930 Ferry Park Ave., Detroit, Mich. .....B
Mark Wade, District Mngr., Oxweld Acetylene Co., Long Island City, N. Y.....B
W. A. Armstrong, Salesman, John A. Roebling's Sons Co. of N. Y., 500 Morgan Bldg., Buffalo, N. Y.....C
Phillip Bourque, Welder, Y. M. C. A., Detroit, Mich.....C
John G. Burkhardt, Proprietor, Champion Welding & Mfg. Co., 519 Ellicott St., Buffalo, N. Y....C
John G. Kjellgren, Elec. Engr., Lidingo-Brevik, Sweden C
Wm. D. McConnell, Acetylene Welder, Detroit St. Railway, Detroit, Mich. C
Geo. B. Malone, Welding Instructor, Southern Railway System, Birmingham, Ala. C
Carl D. Miller, Mngr., Buffalo Office Burke Electric Co., 500 Morgan, Buffalo, N. Y.....C
Geo. T. Rhodes, Supt. of Welding & Bonding, Dept. of Street Railways, City of Detroit, Shoemaker & St. Jean Sts., Detroit, Mich. C
O. E. Shelstad, Supervising Welder, Fairbanks, Morse & Co., Beloit, Wis. C
John F. Burkhardt, Mngr. Operator, Champion Welding & Mfg. Co., 519 Ellicott St., Buffalo, N. Y. .....D
Fred H. Cooper, Electric Welder, Sumner Iron Wks., Everett, Wash. .....D
G. W. Dunaway, Elec. Welder, 1013 Broadway, San Antonio, Texas .....D
Claude M. Gehlert, Elec. Welder, G. H. and S. A. R. R. Co., San Antonio, Texas .....D
Ingard Hansen, General Mngr., "Sveis & Flytekran A/S," Strandgaten, 115, Bergen, Norway .....D
Gerhard Landmark, Oxy-Acetylene & Elec. Welder, P. O. Box 455, Benoni, Transvaal, So. Africa .....D
Chas. H. Maxey, Electric Welder, Southern Railway System, Birmingham Ala. .....D
Wilfred Morrill, Welder, The Electric Cable Co., Bridgeport, Conn. .....D
Lloyd D. Warneka, Welding Foreman, D., L. & W. R. R. Loco. Shops, Scranton, Pa. .....D
Walter E. Zimmerman, Electric Welder Helper, U. S. Government, Cristobal, Canal Zone.....D

EMBLEM

All members of the Society are privileged to wear the Society emblem. Emblems may be obtained in two styles from the Secretary's office.

Price, gold-filled, 75c; 14-K. gold, $5.00.

EMPLOYMENT SERVICE BULLETIN

Opportunities.—The Society is glad to learn of desirable opportunities from responsible sources, announcements of which will be published without charge in the Bulletin.

Services Available.—Under this heading brief announcements (not more than seventy-five words in length) will be published without charge to members. Announcements will not be repeated except upon request received after an interval of three months; during this period, names and records will remain in the office reference files.

Note.—Copy for publication in the BULLETIN should reach the Society's Office not later than the thirtieth of the month if publication in the following issue is desired. *ALL REPLIES should be Addressed to the Number Indicated in Each Case and Mailed to Society Headquarters.*

Services Availab'e

A-22. An executive and recognized authority on welding who is capable of taking charge of and developing to the fullest extent the possibilities of welding in all of its forms in an industrial organization. Affiliation as Chief Welding Engineer is desired with a large corporation in which welding can advantageously be substituted for riveting with or without possibilities which might be inherent in said corporation for salvaging costly equipment by the use of welding and thus save annually large sums of money.

A-23. Electric Welder desires position. Have completed a course on electric welding and served for five weeks on production work using automatic welding machine. Am now located in South America and desire to secure position. Have also had about five years' experience on the Dominican Central Railroad along this kind of work.

A-24. First-class welder desires position. An expert welder from the Pacific Coast who has had three years of oxy-acetylene welding experience and five years of electric welding on high pressure pipe lines, dredge pipe and tank work wishes to locate in the East. Have had executive responsibility on some of the largest high pressure large diameter pipe lines built in this country and have had successful experience in welding cast iron flanges to steel pipe. Wish to locate permanently with a firm who is desirous of a competent man capable of handling both electric and oxy-acetylene welding.

A-25. First-class electric and acetylene welder with seven years' experience wants steady position. Can set up own work, willing to travel, salary no object, railroad shop, shipyard and boiler shop experience.

A-26. First-class all around electric welder; seven years' experience in repair and construction work, desires position in New York City. Six years as electric welder in Greece and one year with Lehigh Valley Railroad.

Design of Welds—Flexibility Versus Rigidity

There is a wide difference of opinion among experts as to whether a weld in a structure should be designed more rigid or flexible than the parts which it joins. This subject has accordingly been selected as the topic for discussion at the annual meeting. Recognized experts in each of the welding fields have been requested to prepare short papers outlining their views. These papers are given below. The Society is in no way responsible for these opinions but invites discussion of all its members who are interested. Discussions that are intended for publication should be sent in as soon as possible to W. Sparagen, Editor, Journal of the American Welding Society, 33 West 39th Street, New York City.

Carbon Arc Welding

J. C. LINCOLN, Vice-President, Lincoln Electric Co.

There is a great deal we do not know about what happens when a weld is made by the carbon arc process. The same is true of a weld made by the metallic arc process. There are some things we do know.

1. The heating of the metal is very rapid; as the arc progresses along the joint, the metal that is melted is raised from room temperature to at least the melting point of steel in a fraction of a second. At this elevated temperature, some action takes place that propels the metal from one side of the crater to the other. The metal is propelled from the side of the crater that the arc is approaching to the side of the crater the arc is leaving. This force transfers from one side of the crater to the other 15 or 20 lb. of steel per hour when an arc of about 300 amp. is used under proper conditions. The action of the metal in a carbon arc, as well as the action of the metal in the metallic arc, can be explained on the assumption that steel at freezing temperatures or at the melting point dissolves large quantities of gas and that the capacity of steel to retain gases in solution decreases rapidly as the temperature of the steel is increased. As an analogy, the capacity of water to dissolve ammonia gas is very great at 0 deg. C., the melting point of water. At this temperature it will dissolve nearly 2000 times its volume of ammonia gas. As the temperature of the water is raised its capacity for holding the gas in solution decreases until at the boiling point of water, practically all the gas has been driven out. The metal in both the carbon and metallic arc acts as if gas was evolved in or behind the heated metal and this acts as a blast to propel the metal from the hot side of the crater to the cool side, and from the metallic electrode to the work, even when the work is above the electrode as in vertical welding.

2. It is clear that in either the carbon or metallic arc the metal is raised in the fraction of a second, roughly 2000 deg. C. It is also clear that the temperature of the metal after it has passed across the crater in the case of the carbon arc and across the arc

in the case of the metallic arc falls with extreme rapidity. The rate at which the metal cools is much lower than the rate at which the temperature is raised, but even then the temperature of the metal falls with the same order of rapidity that the temperature of metal falls when it is quenched in water.

The practical question is what kind of metal have we in the weld after it has passed through the arc? The assumption is sometimes made that this metal is ordinary cast steel. In some respects this assumption is not justified by the facts.

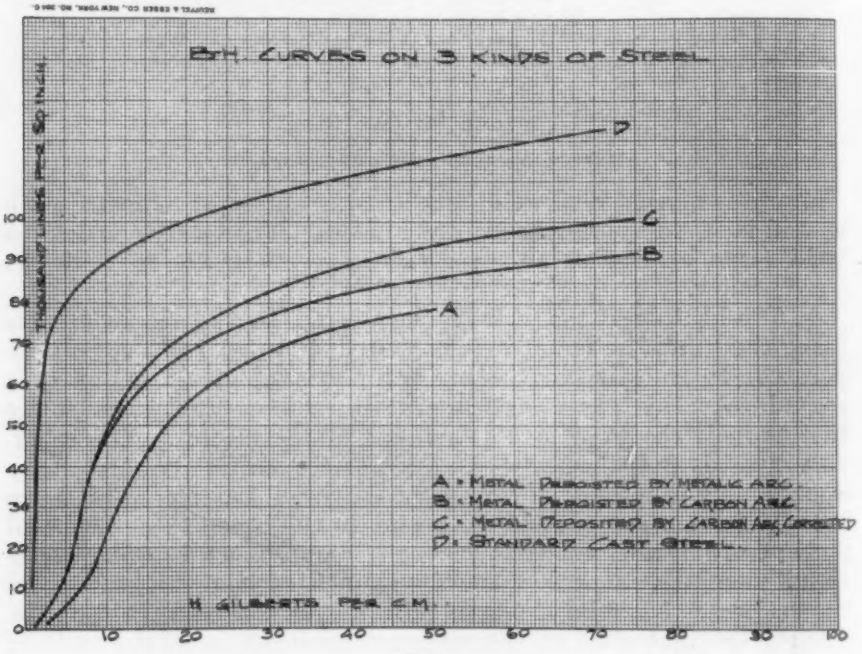

Fig. 1

The tensile strength of the steel after it has passed across the crater is almost equal to that of the original steel. Unfortunately, the ductility of the weld metal is not as great as the ductility of a good, ordinary cast steel. It is my opinion that improvement in the art of electric arc welding must be made in the direction of increasing the ductility of the weld metal. Another indication that weld metal is not ordinary cast steel is the fact that it will not stand up under prolonged heating at a bright red heat or above nearly as well as the ordinary steel casting.

Several years ago, in an effort to get additional information on the nature of weld metal, the writer had test samples made up from which the B-H curves could be made up. One sample was made of metal that had passed across the metallic arc and another sample of metal that had passed across the crater of the carbon arc. These samples were turned down so the final size was ½ in.

diameter and 10 in. long. Mechanically the metallic arc sample was superior to the sample made by the carbon arc. There were a number of gas holes in the carbon arc welded sample which reduced the effective cross section at least 10 per cent. The samples were treated by the Case School of Applied Science and the results are shown in Fig. 1. Curve A is the B-H curve for the metallic arc sample. Curve B is the B-H curve for the carbon arc welded sample. Curve C is an estimate of what Curve B would have been if it had been free from holes and mechanically equal to the metal in Curve A. Curve D is the B-H curve for ordinary cast steel.

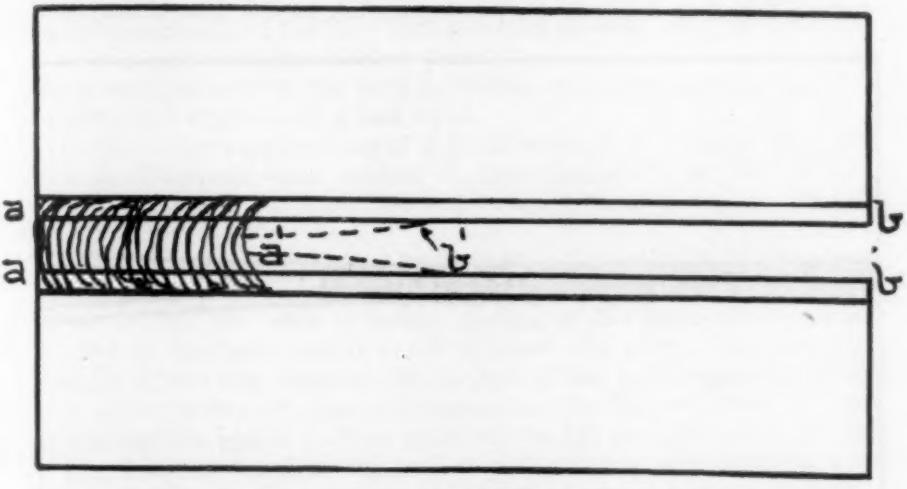

Fig. 2. Full lines *ab* original edge of plate; broken lines *a'b'* edge after expansion. The expansion of metal in plates ahead of weld draws plates together in cooling.

To my mind these curves show that the molecular structure of metal after it has crossed a metallic arc or passed across a carbon arc crater is quite different from the molecular structure of cast steel. It will be seen that these curves are similar to that of a pile of thin sheet iron discs made into a pile ½ in. in diameter and 10 in. high. It looks as if the iron particles were separated by something in the same way that the metal on the adjacent discs is separated by a layer of oxide. Attention should be called to the fact that the B-H curve for the carbon arc welded metal is better than for the metallic arc welded metal. My explanation of this fact is that the metal in passing from one side of the crater to the other in the carbon arc process is not heated to as high a temperature as the metal is heated in passing across the metallic arc. The practical result of all these considerations is that in the present state of the art we cannot expect metal of the highest ductility in the weld metal and that it is not to be expected that this metal will stand repeated bending as well as metal of a different structure

and that, therefore, the welds must be made so as to throw any bending strains outside the weld.

In other words, the weld must be made rigid so that any possible bending will occur outside of the weld. Therefore welds should be made rigid and not flexible.

Flexible and Rigid Methods in Preparing for Welding

I understand it is the general practice in gas welding to start the welding of two plates with an opening at the far end of the plates. As the welding proceeds these edges are drawn together by the contraction of the metal in the weld and plates as they cool. The same method is very often used in welding by the metallic process. What happens to a couple of plates when the edges are welded together depends on the expansion in the plates near the

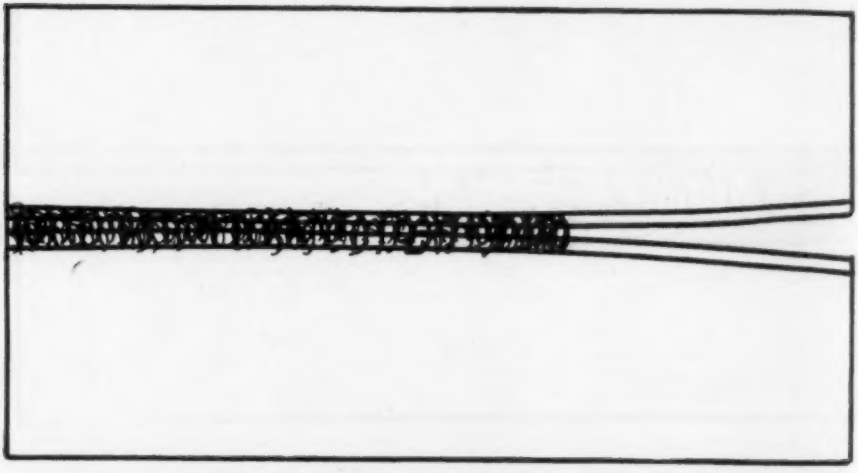

Fig. 3. Expansion of the edges of the plates tends to open up the plates at the far end.

arc, due to the local heating. The strains set up by this local heating are hard to follow completely and it is likely that they are controlled by a number of factors. I will briefly discuss two factors which control to a great degree the strains in the plate and, therefore, dictate to a great degree the proper method of welding. It seems to me to be a safe statement that the locked-up strains in a weld are more largely due to the heating and cooling of the plates than to the cooling of the weld metal. The best study of locked-up strains in welds can best be made by studying welds in cast iron. The volume of melted steel is about 7 per cent greater than the volume of the same metal cold. There is, therefore, about the same shrinkage in the weld metal when welding cast iron as when welding steel. The tensile strength of cast iron is about one-third that of steel. Therefore, a given strain in cast iron is three times as likely to produce a crack in the iron as in the steel. The greater ductility of the steel as compared with cast iron greatly increases

this ratio. Experience in cast iron welding shows that heating of the edges of the plates to be welded must be reduced to the minimum in order to prevent cracking due to cooling strains. It is impossible to prevent the cooling strain due to the cooling of the melted weld metal, but experience shows that it is possible to do very difficult cast iron welding if care enough is taken to avoid excessive heating of the edges of the plates to be joined. This is done by welding half an inch or more and then letting the weld and plates cool before doing any more welding. The shrinkage of the weld metal is the same whether the cast iron is welded continuously or in short steps waiting for the metal to cool between steps. The local heating of the cast iron is less in the step by step method and the fact that the step by step welding produces a weld in cast iron less liable to crack indicates that the heating of the metal adjacent to the weld is, in this case, the determining factor between a good and a bad weld.

In the continuous welding of a joint between two plates there are two chief actions—one tending to close the plates at the far end of the weld and the other tending to open these plates at the far end.

Fig. 2 is a sketch intended to show that any heating of the edges of the plates ahead of the weld pushes this metal toward the other plate. After the weld is made, cooling of the plates, as well as cooling of the weld metal tends to draw the plates together and thereby draws the plates at the far end of the weld together. That this action exists is generally recognized by the common practice of leaving the plates farther apart at the far end than at the weld.

Fig. 3 shows what would tend to occur if the weld between two plates was made all at once as it is by the thermit process. In this case it is clear that the plates would have a tendency to open up at the ends.

It is evident that if the weld could be made quickly enough from one end to the other, that the same effect would appear. The question whether the plates tend to approach each other or to draw apart as the welding progresses is, therefore, determined by the *time* required to make the weld. If the weld is made slowly enough the effect shown in Fig. 2 will determine the result, for with slow welding, there is greater heating of the metal and, therefore, greater expansion ahead of the weld. Also, the expansion of the metal behind the weld becomes more general as soon as the heat is evenly distributed through the plate, and therefore, the effect shown in Fig. 3 decreases. On the other hand, making the weld rapidly decreases the heating, and, therefore, the expansion of the metal ahead of the weld, thereby decreasing the effect shown in Fig. 2 and at the same time increasing the effect shown in Fig. 3.

Experience with automatic carbon arc welding shows that at a speed of about 1 ft. per minute the effect shown in Fig. 3 is greater than the effect shown in Fig. 2, and that the plates open up as the weld progresses. The sample I have here that shows this effect

is about 3/16 in. thick and each plate is 3 in. wide and 20 in. long. When the welding operation started the two plates were in contact. The ends are about 3/16 in. apart after welding.

The conclusion is, therefore, that if the right speed of welding is selected that the effects shown in Figs. 2 and 3 may be made to balance each other and thereby eliminate warping.

Gas Welding

S. W. MILLER, Research Engineer, Union Carbide & Carbon Research Laboratories

The need for defining at the start the meaning and scope of the subject seems evident. Both flexibility and rigidity are used in different senses, and in whatever sense they are used they are only understandable, except in pure theory, when they are used as comparative terms.

Rigidity means, in its fullest sense, that property of a substance which prevents it from being changed in form by any applied force either internal or external. A perfectly flexible substance is one that can offer no resistance at all to any force. Our experience shows that no such substances exist, and so we must content ourselves with using familiar materials as instances of what we mean.

As we are by our subject confined to the consideration of welds, we are thereby also limited to the consideration of metals. We well know that a thin sheet of almost any rolled metal is flexible; that is, it can be easily bent. Whether it will return to its original shape after bending is another matter.

It is evident that a piece of steel .01 in. thick and 4 in. square can easily be bent by the fingers, but that a piece 1 in. thick and 4 in. square cannot. On the other hand, if the 1-in. thick piece were 30 ft. square and we could lift one edge, it also would be flexible; that is, it would bend easily.

We must, therefore, limit our subject in such a way as to make comparisons possible. As I see it, what is really meant by our subject is, should a weld have the same degree or a different degree of flexibility as the piece in which it is made.

It seems obvious that the ideal weld is one which has exactly the same physical properties as has the piece in which it is made, whatever these may be. But we know from experience that it is unusual to get this result.

A weld is a casting, and the same properties cannot be obtained in a casting as in a forging. The cooling rate of a casting made in a sand mold is different from that of a weld made in that casting, and this alone creates different properties. Differences in chemical composition between base and added metals is another fruitful source of difference in properties.

Everything considered, I know of no instance in which it is possible to obtain in a weld the same physical properties as in the

base metal. In cast iron the weld is always stronger than the base metal. In soft steel the ductility is always less, and the strength usually lower. In brass and bronze the conditions vary greatly as to the strength and ductility of the base metal, so that it is not possible to generalize as to the relative physical properties of base metals and welds.

We can, however, go so far as to say that, as a usual thing a weld in wrought metal has less elongation and reduction of area than the base metal, largely because it is a casting. In cast metals the properties of the weld are usually more nearly those of the base metal, though never exactly the same.

In any kind of joint it is desirable to have an efficiency of 100 per cent and it seems to me that since we cannot expect the same properties in the weld as in the base metal, the practical question is, what can be done to arrange matters so as always to avoid breaking in the weld in service, in cases in which breakage would be serious, and if this cannot be done, how far can we go toward accomplishing it? As an illustration, a weld made in soft steel plate with ordinary low carbon wire, a very common combination, has usually less tensile strength per square inch of section than has the plate. We can increase the total strength of the weld by increasing its sectional area or, as we say, by reinforcing it. This is especially true if the weld be of the double V type. But if the plate be of, say, 60,000 lb. tensile strength, it is not sure that this increase will make the weld stronger than the plate. Also the strong plate puts stresses into the weld, which may be dangerous in service.

We can help matters much if we insist on using plate of less tensile strength, which is more ductile, so that the weld will be stronger than the plate, and, therefore, the stress distributed over the plate and not concentrated in the weld.

Evidently the same result can be obtained by using suitable high tensile strength welding material with the high tensile strength plate. But here the effect of the heat must be more carefully considered, as a very high carbon plate may be so damaged by the welding as to make it weak and brittle.

Again, it is becoming very common to weld cast iron with bronze, and many jobs can be done this way that can be done only with difficulty, if at all, when using cast iron welding rods. The bronze weld does not have anywhere nearly the same physical properties as the cast iron. Its tensile strength is much higher, its ductility is greater and it has a very low elastic limit. The last property makes it unsuitable for any part that must not give under stress, such as a stamping press frame.

I do not think that we can say categorically that a weld should be either rigid or flexible, as we are limited not only by the qualities of the base metal, but by the possibilities of welds. About as far as we can go is to make certain statements as to what we are able to do or as to what will be suitable in any specific case. We should,

however, always have before us the importance of making a weld having the same physical properties as those of the base metal, and one of our principal objects should be to learn how to do this.

Metal-Arc Welding

C. J. HOLSLAG, Chief Engineer, Electric Arc Cutting & Welding Co.

This subject is so important a factor in the designing of a weld that it is thought necessary to devote specific attention to it. Shall a weld be made to absorb all the stresses of warpage and bending, or shall it be deliberately made to pass these on to the rolled or forged parent metal?

Let it be remembered that an electric arc weld is a casting and, fortunately, a very good casting. By means of improved methods the weld may even be refined to the point of exhibiting the physical and chemical characteristics of the best grade of electric steel castings, which are considered the best. Nevertheless, except in some special cases, it seems fairly obvious that the weld deposit should not attempt to compete in strength with the rolled plate. This plate, originally a casting, has been worked and rolled to a point where it has taken on properties which a plain casting cannot possess.

There is a fable concerning a dog that passed himself off as a wolf very successfully until he attempted to run with the wolf-pack. So an electric arc weld-casting is excellent as such, but cannot be classed with castings which have been rolled and worked. The same observation applies to any forged, stamped or pressed-steel member.

In spite of this, the process of arc welding affords a superior means of joining rolled plates or structural forms. In welding steel or iron castings, it seems apparent at once that the principal result desired is the production of a stiff, solid joint, and that the weld shall possess those properties of elongation and ductility found in a good casting. Under these conditions all parts of the weld should be capable of withstanding the contracting strains of the base metal. Although, in arc welding, these strains are usually very small, they may sometimes be sufficient to produce a faulty weld. This is especially true when the weld is made "cold."

However, if the weld cools without cracking, there need be no apprehension as to the presence of locked-up strains therein. As a matter of fact, the act of stretching steel beyond its elastic limit (although not beyond its ultimate strength) actually results in an improvement in its physical properties of ductility and elongation. If this is so, then the stretching of a steel weld beyond its elastic limit produces beneficial effects in the weld itself, so that no matter how much the weld is strained, if it cools without breaking it may be relied upon. Most welds that crack do so during welding, or

directly after, while the piece is cooling. The reason for this is usually that a cross-section of sufficient strength to withstand the strains of cooling has not been provided. This brings us directly to the point to be emphasized, namely, that all electric arc welds should contain an adequate cross section and adequate stiffness, to be able to transfer all the strains which occur after cooling to the parent metal, which, supposedly, is better able to withstand these strains.

Although stretched steel is improved by moderate working, continued or intermittent stresses applied beyond the elastic limit will cause fatigue and complete loss of strength. Because of the fatigue tendencies of arc-welded steel, which are usually greater than those of worked metal, no live loads exceeding the elastic limit of the weld should be applied to it.

No riveted joint is designed to bend, and even the strongest of these joints—the double-butt strap—is certainly not capable of absorbing any of the bending strains within itself. This type of riveted construction is considered satisfactory for every use to which riveting is put; it would seem, then, that the same type of rigid construction would be entirely feasible in a weld. If this is so, the costly and unproductive research for a rubber-like welding material is scarcely justified.

However, let us suppose that such a material were available; an ideal material that would contain all the physical properties of the best forged steel. Even with the use of this wonderful metal, the cross section of a weld should be made as large as possible. Elongation and deformation in a weld should always be avoided, because the most perfect weld is apt to contain minute flaws. To preserve a consistent degree of excellence in every weld, it is best to divert all strains as widely as possible, and not to allow them to be focussed in the weld. All castings are subject to the presence of blowholes, gas pockets and many other imperfections and should be treated accordingly. A steel casting may contain a jet-hole as big as a football and yet pass inspection; faults like these do not materially reduce the factor of safety. A poor weld casting is actually often better than a good poured casting.

**Sometimes in live-load welding an increase in cross-section is not permissible in the member. In this case an extra strong steel weld should be used, or some mechanical means should be devised to conduct the stresses to the metal outside the weld. Like any steel casting, the weld may possibly contain internal flaws, and the chances are that these will occur at or near the boundary between the welded and parent metal, unless both are of the same material. This condition is likely to result in the presence of a weak spot, under severe continuous or alternating stresses. This weak point may be eliminated by so designing the weld that the

**We mean by live load in this article loads under alternating stress, such as revolving members. The live load members in building construction are considered dead load for welding purposes.

stresses will be diverted into the parent metal. In operations upon cast iron the steel arc weld is a better joining medium than the base metal; hence a weld of this type may be made to possess the capacity of absorbing *all* the cooling strains, and thereafter to hold the casting in its previous rigid state through a link stronger than the original metal. In cast steel welding all the physical properties of the parent metal are easily duplicated and a practicaly homogenous result assured.

In conclusion, we may assume that under advantageous conditions a weld made with average care will withstand the usual stresses with a strength about equal to that of mild rolled steel. Nevertheless, it is best to remember that a weld is a casting and always will be a casting, unless some method of forging is used. More progress may be made in the art of welding if its basic capabilities and limitations are frankly taken into account.

Questions on "Rigidity vs. Flexibility in Arc Welding"

1. Why is an arc weld necessarily a casting?
2. Is such a casting one of good grade? Why?
3. Why is rolled or worked metal better than a casting?
4. Can plates or other members be reliably joined by means of a casting?
5. What result is produced by stretching steel beyond its elastic limit?
6. What result is produced by stretching steel beyond its ultimate or breaking strength?
7. How should live-load members be welded?
8. How do the physical properties of an arc weld compare with those of cast steel? Of cast iron?
9. What is the Rigid system of preparation?
10. What is the Non-Rigid system of preparation?
11. To which is each best applicable?
12. Which system is better where practical?

Resistance Welding

H. A. WOOFTER, Electrical Engineer, Thomson Electric Welding Co.

The service required by a welded joint determines whether or not the weld should be rigid or flexible. Welds in large machine tools, drill and reamer shanks, drill rods, rock drills and automobile and truck axles should be as rigid as the parent metal of the stock itself. The reason for this is apparent, for if the welded joint were more flexible than the parent stock it would be but a matter of a short time until crystallization would take place at the most flexible point, namely, the weld. In actual practice, however, the weld in such articles as quoted above is more rigid than the parent metal due to the pressure applied to push up the weld which compresses the metal, bringing the molecules closer together more

in the nature of a drop forging. Consequently, axles, drill rods, drills, etc., which have been welded invariably break at some other point rather than the weld. We have broken axles coming into our job welding department, some of which show two or three, or even four previous welds which are still sound.

In welded joints in loom flyers, band saws, knife handles, mowing machine cutter bars, rug splitting knives, etc., the welds must be flexible because some of the articles are under an almost continuous bending movement, as, for instance, band saws, flyers and rug splitting knives. This flexibility can be secured by annealing the weld, preferably immediately after it has been made. This can be done by several different methods, and the particular method chosen should be determined by the requirements the article must meet in service. Welds in band saws are usually annealed immediately after welding in the welder itself by moving the clamping jaws somewhat farther apart than for welding, reducing the secondary voltage of the welder and heating the weld and sections adjacent thereto up to a dull red. In some cases one of such heatings is sufficient. In other cases, such as loom flyers, it is necessary to heat the piece in an oven and quench it in oil, sometimes as many as six times successively in order to secure the proper grain structure and flexibility in the welded joint. The great majority of resistance welds made in production require no annealing or quenching whatever. This is particularly true of the present practice in making automobile rims, truck wheels, bicycle frames, automobile cranks, farming implements, etc. All of the above come within the class of resistance welding known as butt welding.

Spot welds, in general, are not required to be flexible. The process takes the place of riveting, which is usually made as rigid as the riveter could make it. Seam welds, however, are sometimes required to be flexible in the plane at right angles to the face to facilitate rolling or forming, as in the case of barrels, containers, automobile bodies, etc. The welds in mechanical tubing, although made by the straight butt welding process, take on largely the nature of a seam weld, and as such are required to be flexible, in that the tubing must stand bending on a fairly small radius, as in the case of frames for beds, etc. It is also common practice to make a seam weld by a series of elongated spot welds. These welds must be flexible, as in the case of welded aluminum sheets or steel sheets, which are later drawn or pressed into automobile bodies, containers, etc. Welds in copper rods must be flexible, since the rods are often drawn into smaller sizes, sometimes into small wire.

Thermit Welding

J. H. DEPPELER, Chief Engineer, Metal & Thermit Corporation

One would naturally think that consideration of the relative stiffness of welds and parent metal would refer principally to the

oxy-acetylene and to the electric welding industries, and this is essentially so because in these there is the enormous field of sheet-plate and tank welding where, due to the size and importance of the application and the undisputed advantage of welding over riveting, the entire procedure of the making and rolling of sheets might very well be revolutionized to suit the newer process.

Thermit welding, on the other hand, has no such single enormous field of application. It occupies an important position, but one in which the application is more varied; for instance, like the acetylene and the electric jobbing work magnified in size.

It is obviously impractical to even consider the manipulation of such a variety of parent metal as locomotive frames, crankshafts, stern frames, rudder stocks and the multitude of heavy iron and steel pieces and, therefore, the only place where such a procedure might even be considered is in the material used in street railway rails, and here the requirements of the wearing qualities under the rolling action of the car wheels is paramount.

In considering the softness or hardness, ductility or stiffness of a thermit weld therefore, the parent metal must be taken practically as it comes.

Fortunately, the thermit process lends itself perfectly to the production of a wide variety of steels with physical properties definitely within control. A slight consideration of the thermit process in its various ramifications will make this evident.

Thermit is fundamentally a mixture of the purest iron oxide and virgin aluminum, which when ignited in one spot will progressively react and produce in a fraction of a minute any desired amount of molten iron on top of which floats the slag aluminum oxide, both at the almost incredible temperature of more than 5000 deg. F. This reduction process is very similar to that in which ordinary iron is made, except that aluminum is used as a reducing agent instead of carbon and that pure iron oxide is used instead of the impure iron ore. Aluminum is a much more active reducing agent than carbon and consequently does not require the application of the prolonged heating used in iron and steel production. The layman often wonders why, since one process takes only a fraction of a minute to produce the same weight of steel that the other takes many hours, this aluminum reduction or thermit process is not not used for all steel production. The answer is obviously that the aluminum reduction process is much more expensive than the ordinary steel production process. The great advantage of the aluminum reduction or thermit process lies in the great purity and high temperature of the alumino-thermic steels.

Now considering the matter further, if instead of iron oxide and aluminum one mixes other metallic oxides and aluminum, other metals are produced. In this way are produced all the long line of carbon-free metals used in the steel industry, such metals as chromium, manganese, cobalt and the ferro alloys of titanium, tungsten, vanadium, molybdenum, chromium, etc.

Now it would seem that we had wandered far from our subject, but really this is not the case, because when we realize that all these elements—iron, chromium, manganese, etc.—are all produced in the same manner except that different oxides are used, we realize that combinations of these oxides will produce combinations of these elements or, in other words, that pure iron can be produced in combination with any predetermined amounts of these other elements. Imagine what enormous possibilities there are here. As a result thermit welds can be produced with tensile strengths varying from 60,000 lb. per square inch to 110,000 lb. per square inch and no one knows how much higher, and with elongations varying from 33 per cent down to practically nothing.

This simplicity of control makes it possible to design thermit mixtures which will produce steels either extremely ductile with good tensile strength or less ductile with very much higher tensile strength, and our present product has both of these properties, we believe, very well balanced, resulting in a tensile strength of about 75,000 lb. per square inch and about 25 per cent elongation. We do this on the theory that the weld should be as nearly as possible the same strength and stiffness as the parent metal because if it is less stiff or, in other words, more ductile, all bending will be localized in the weld, the metal gradually fatigued and eventually fail, whereas, if it is less ductile than the parent metal, bending will take place at the junction of the weld material and parent metal and again early failure may result.

In practically every case we believe that the welded structure should be uniformly flexible and that a change in flexibility from one point to another, due to fillets, cross members or other features of design, are the principal cause of failures and breakages, and are due to the localizing of bending stresses at one side or another of these stiff points. In other words, we strongly recommend that wherever possible in welded structures, the weld material should be as nearly the same in its physical properties as the parent metal as possible and that if this cannot be accomplished, it would be better to have the weld slightly more ductile than the parent metal, as otherwise we would have frequent failures alongside of the weld due to the same reason that causes failure in mechanical fittings in pipes where, due to the stiffness of the extra weight of metal at the coupling, bending stresses are localized in the pipe at the end of the coupling and practically all pipe failures occur at this point.

The American Welding Society invites discussion of this important subject for publication in the Journal

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Reclamation of Cast Steel Car Castings by Arc Welding*

H. R. PENNINGTON†

It is comparatively recent, probably within the last five years, that the practice of reclamation in this field has been accomplished in a reliable and satisfactory manner. Even at the present time the practice is not extensive, mainly due to interpretation of the Interchange Rules of the American Railway Association, these rules having been drawn before the arc process came into general use on railroads and were intended mainly to facilitate oxy-acetylene welding.

The use of cast steel castings coming under this classification, such, for example, as coupler bodies, knuckles, truck sides and bolsters, are rapidly and constantly increasing. Obviously, the question of reclamation of such parts has assumed more and more importance with their increased use. At the present time the rate of development of defective castings amount to considerable tonnage per month, on individual roads of average size.

Examples of the potential savings in this class of work is shown below from results of test and records of actual practice.

New coupler body, price each, approximately	$17.00
Average cost reclamation, each	2.13
Savings	$14.87
New truck sides, price each, approximately	$20.00
Average cost reclamation, each	7.14
Savings	$12.86

Truck bolsters, etc., afford similar savings as the examples given. The guaranty on such castings are from three to ten years. Such parts failing under their guaranty period possess only scrap value; when reclaimed, however, this value is retained. To give some conception of the volume involved, assuming a railroad operated 50,000 freight cars (there are many roads which operate a much greater number) it would have in service 200,000 truck sides. Although all truck sides are not cast steel, most all roads are adopting them and have been for a number of years. Assuming 50 per cent of the above number to be cast steel, and, if the average life is twenty years, which, according to the records is conservative, the annual depreciation would be at the rate of $100,000 a year. If 50 per cent of this value can be reclaimed, which is also conservative, the annual savings represented by this one item alone, based on example given above, would be, roughly, $35,000. A few roads

*Presented before January, 1924, meeting of Northern New York Section, A. W. S.
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are realizing such savings on this and similar items, but in comparison to the potential savings on all of them, the surface has hardly been scratched.

While engaged in railroad work an opportunity was afforded me to observe results of the welding on steel castings as generally

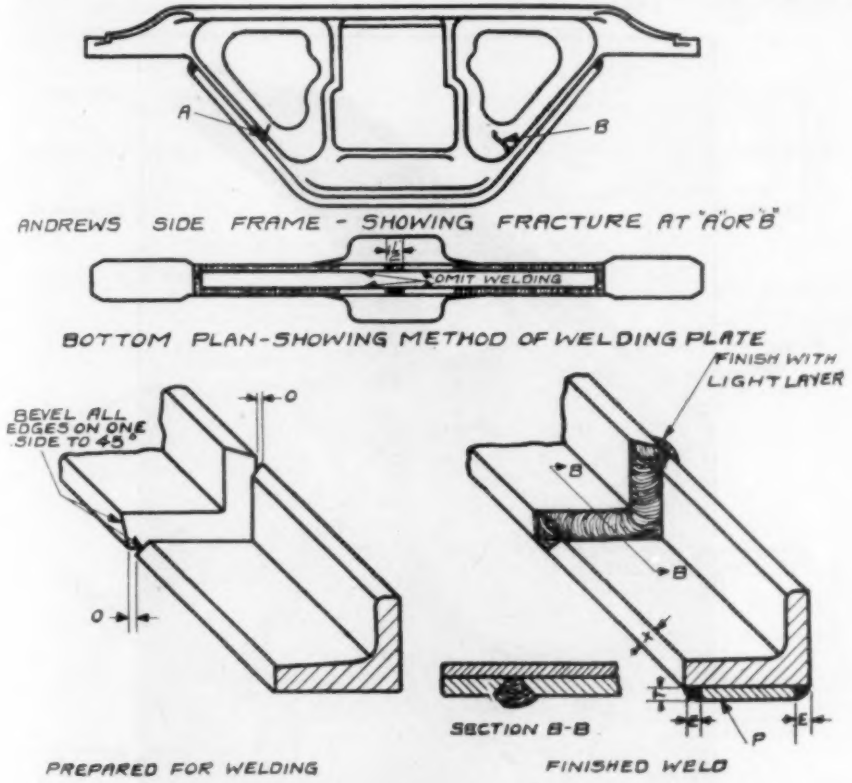


Fig. 1. Welding truck side tension member.

practised. This practice in a majority of cases amounts simply to bevelling the fractured edges and welding, without special consideration or attention on the part of anyone. The result of this practice has been very unsatisfactory, in some instances causing failure in service of such vital parts as truck sides, with attendant derailment of trains in at least two instances on a single road, to the writer's knowledge. Additional evidence of the fallacy of improper applications of welding to such parts was found by the fact

that parts so welded failed after a very short period of service, seldom exceeding one year.

In view of the above, it is felt that the outline of a practice for reclamation of such parts, which has been in use over four years, with no greater percentage of failures than that of new and unwelded similar parts, should be of interest.

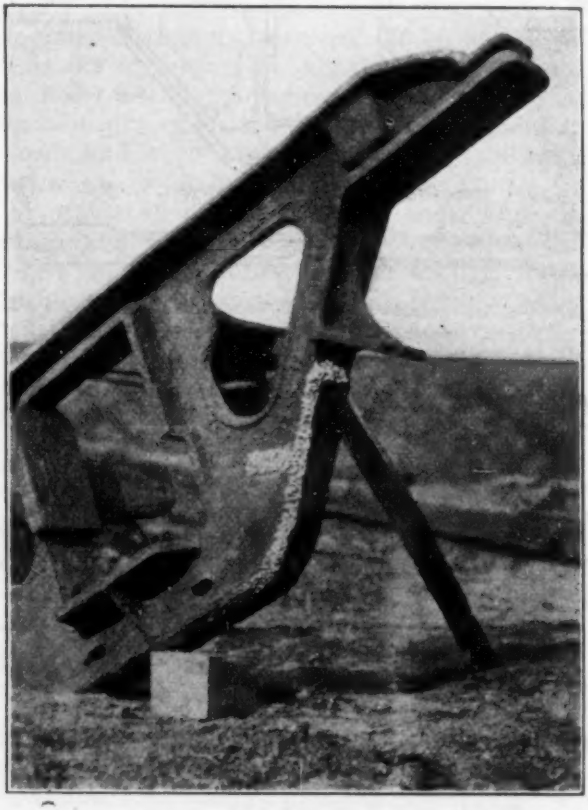


Fig. 2. Truck side casting reclaimed by welding.

Further, it is hoped that this practice will form a basis for the determination of a practice to be recommended for presentation to the American Railway Association on Interchange Rules.

RECOMMENDED PRACTICE

The first consideration of a fractured part is whether or not the part is primarily fitted to be returned to service. To determine this, before any preparation for welding is done, the fracture and a considerable area in its vicinity should be cleaned by sand blasting to expose any defects. A close inspection of the completed part should then be made. If an unusual number of defects are found, such as gas pockets, sand holes, shrinkage cracks, porosity,

etc., the casting should be discarded and not welded, especially if such defects are present in the tension member of the part. In addition, such parts should not be welded unless it is possible to increase the sectional area completely over the defective portion by not less than 50 per cent. By defective portion is meant not only the fracture, but any neighboring metal that may indicate weakness due to imperfections in the casting.

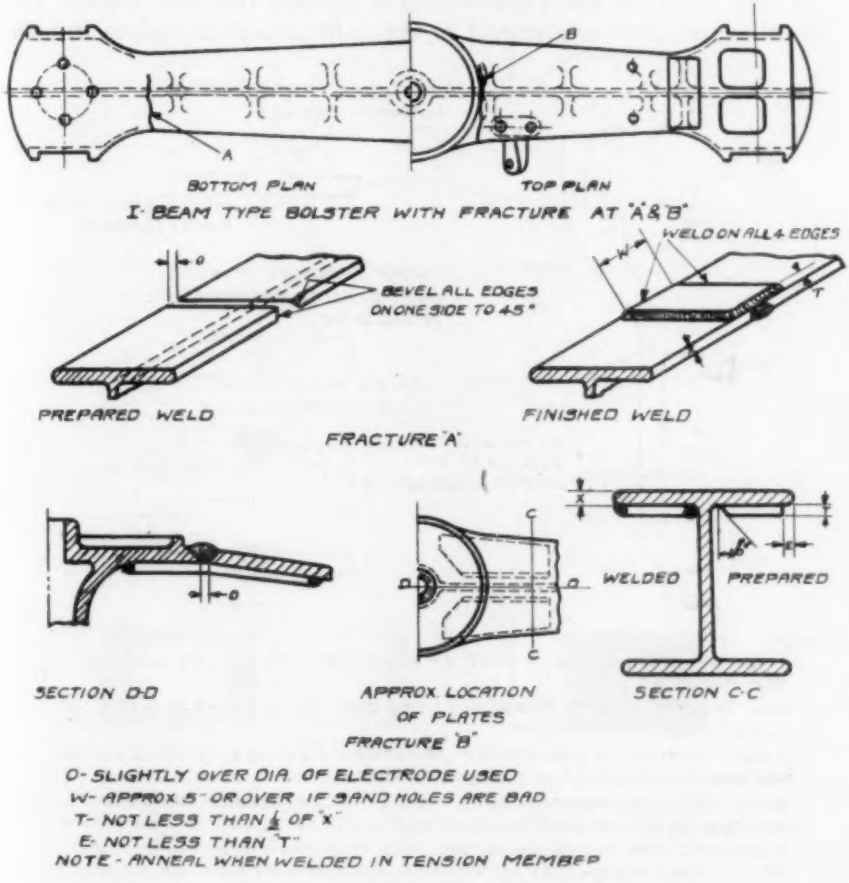


Fig. 3. Repairs of castings that have failed through fatigue

TYPE OF JOINT

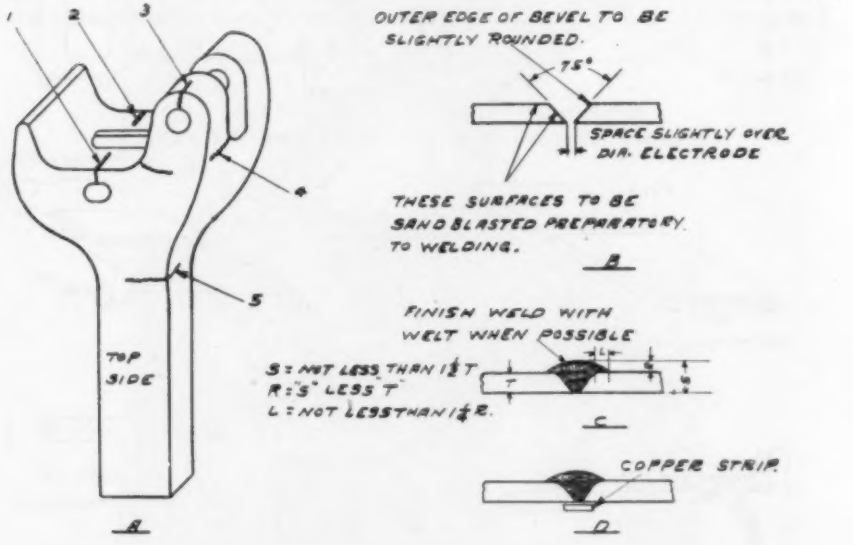
The proper reinforcement is best and most efficiently provided by the use of a strap type of joint, the strap being applied on the side opposite from which the welding is done. In the case of tension members on truck sides, the practice of extending a reinforced plate along the full length of the tension member is felt to be advisable, this practice being arrived at, after extensive use of narrow reinforcements, both by building up and by use of a short strap type of joint, which in service resulted in failures adjacent

to the reinforced area. It seems that the increased stiffness of a localized reinforcement concentrates the strains adjacent to the reinforcement, resulting in failure at this point.

Sketch, Fig. 1, shows recommended reinforcement of truck sides tension members, together with preparation of fracture.

Photograph, Fig. 2, shows a similar casting reclaimed as described.

Truck bolsters are repaired in a similar manner, except that the reinforcement is confined to the defective area, unless in cases



NOTE:-

MOST ALL FRACTURES IN FACE OF COUPLERS ARE AT TOP SECTION, FRACTURE NO. 1

ALL WELDS EXCEPT POSSIBLY NO. 3 CAN BE FINISHED WITH A SLIGHT WELT.

WHEN COUPLER IS SPRUNG AT FRACTURE NO. 1 OR 2, IT SHOULD BE HEATED AND PRESSED INTO PLACE - TO GAUGE.

WHEN WELDING FRACTURES NO. 1 OR 2, IT IS ADVISABLE TO PLACE A COPPER STRIP OR ROD, ON REVERSE SIDE OF "V" (D) TO SERVE AS A BACKING FOR FUSED-IN METAL AND TO ELIMINATE POSSIBLE PROJECTIONS WHICH MAY INTERFERE WITH OPERATION OF COUPLER LOCK.

Fig. 4. Reclaiming couplers.

where a certain class of equipment or, rather, a certain type of bolster, is found to be of a weak design, in which case fractures are repaired and reinforcement similar to that of truck sides is applied to the tension member of bolsters.

Sketch, Fig. 3, shows recommended method employed where castings are originally of proper design and have failed only from imperfections or fatigue.

Sketch 4 and 5 show recommended practice for reclamation of couplers.

ANNEALING

Although proper and careful workmanship, methods, etc., are essential to successful reclamation, no less is the importance of proper and careful annealing of such parts after welding. The necessity for this is obvious, since in most all cases there is no occasion for reclamation until the metal of the part has developed

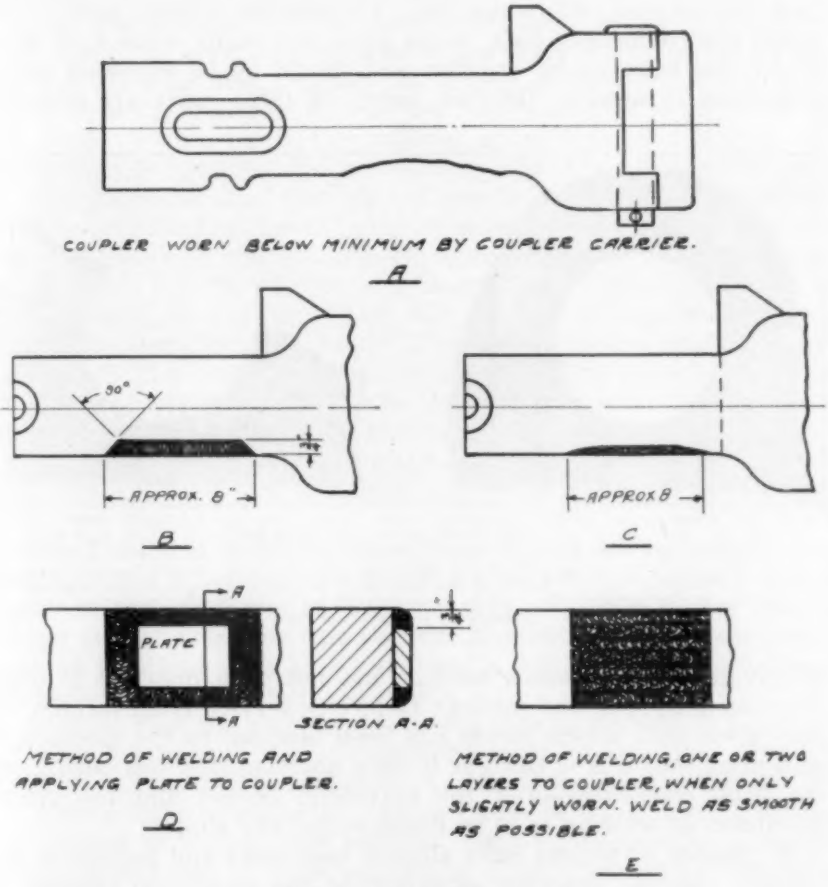


Fig. 5. Reclaiming couplers.

fatigue, and although this weakness may only be evidenced at the point of fracture, for commercial purposes, it is safe and should be assumed that the neighboring matter is at or near the point of failure, and unless the initial cause of failure is removed, the repairing of the fracture is practically useless. In addition, the ill effects of the welding operation on base metal, as well as strains resulting from welding, should and must be removed if satisfactory results are to be expected. *All of this is taken care of by a*

thorough annealing of the complete part after the welding has been performed.

The importance of annealing as a part of reclamation is such that unless made a part of the process such repairs are not to be recommended. Although the investment in the proper facilities for annealing will in most cases be equal to the investment of the welding equipment, this same annealing facility will serve to give like treatment to other similar parts used on both freight cars and locomotives. Examples are: Cross-heads, guides, piston rods, main and connecting rods, crank pins, and many other such parts which are built up by welding and should all be annealed before returning to service. In fact, many of these parts are annealed

Fig. 6. The above are cross sections of eyes from couplers which had been reclaimed by welding the eye on. Attention is called to the shrinkage crack in the upper left hand part of the complete eye. Also to the porous condition of the metal in the weld and to the extremely porous condition in the original metal in the broken eye. Also, note should be taken of the hardened area caused by the welding heat

to advantage, even when welding has not been involved in order to prolong the life and prevent failure in service from fatigue. It may seem that undue stress has been directed to the question of annealing, but this is thought to be a question that has been given too little consideration if the maximum benefit and the proper extension of welding is to be made in railway shops.

A number of papers have already been read and printed in the Society Journal, drawing attention to the structural changes in parts resulting from welding. These incidental effects should not be allowed to hinder the progress of welding, and for most cases the effect can be eliminated by the simple process of annealing. Assuming no bad effects from welding, when it is considered that by virtue of building up or making repairs of parts that the service is extended to such parts, in itself gives reasons for the necessity of restoring the normal structure which may have been impaired by previous service.

No detail of preparation of procedure in the actual execution of the welding has been outlined, as the methods generally used are

suitable. The reference in the beginning to Interchange Rules refers particularly to Section 2, which reads as follows: "Welding practice of fractures will not be permitted on the following: Among other parts are included coupler bodies and knuckles." In reclaiming, as above outlined, it is thought these two items could and should be removed from the list of parts on which welding is not permitted. Another restriction is that of Section 4, under the heading "Welding cracks or fractures will be permitted on the following:" Among other parts, cast steel truck sides and cast steel bolsters are included, with the restriction that welding is permitted only when the area of the crack is less than two-fifths, or 40 per cent, of the total area through the section at the point of fracture, but it is not permissible to weld a crack located within 6 in. of an old weld. With a method as outlined above it is not felt that this restriction is justified, for the reason that if a reinforcing plate equal to 50 per cent of the original area is applied, that this should be the equivalent of the 40 per cent requirement above mentioned.

In reference to the question of rigid inspection before welding, photograph, Fig. 6, will serve to illustrate the importance and is self-explanatory. If the failed part had been inspected, as outlined, the imperfections would have been exposed and the part discarded. Incidentally, this photograph will also serve to show the necessity of annealing to remove the hardened area caused by the welding heat. No special reference has been made to the question of reclamation of coupler knuckles. For this purpose the following should suffice: Coupler knuckles condemned for wear or minor fractures should be restored by welding when the cost of work required for reclamation will allow a saving over the cost of a new knuckle. Consideration should also be given to the fact that in many cases a reclaimed knuckle will give only from 50 per cent to 75 per cent as much life as a new one, this being due to wear occurring in locations such as a knuckle pin hole, which cannot easily be corrected by welding.

In order that the maximum economy may be realized in this class of work, equipment of ample capacity must be provided. The use of high arc current is facilitated by the heavy section and by use of proper welding material. From ¼ in. to ⅜ in. electrodes can be utilized in metallic arc welding, with corresponding increased speed of welding. If such equipment is provided, the applications of reinforcing plates, as shown for truck sides, can be made, for example, in about the same length of time as would ordinarily be required to weld only the fracture with a 5/32 in. electrode.

Special attention has been called to this class of work, as it is not felt the same consideraiton has been given to it as is the case with locomotive parts and repairs, and as a result a vast field for welding application has been neglected, equal almost in importance to that of the locomotive shop.

This will be appreciated when it is considered that there are, roughly speaking, about twenty-five freight cars to one locomotive.

Fluxes and Slags in Welding*

W. SRARAGEN†

Introduction

I have been asked to contribute a paper dealing primarily with the use of fluxes and slags in fusion welding. The material contained in this article constitutes a digest of the opinions of experts in America on the above subject. The action of these fluxes for electric arc, gas and resistance welding will be treated separately; no flux is being used to the knowledge of the author in thermit welding.

FLUXES IN ELECTRIC ARC WELDING

Fluxes play an essential part in steel manufacture in modifying the chemical and physical properties of the resultant product. It is natural, therefore, that in fusion welding, particularly electric arc and gas welding, where in making the weld the metal must be raised to a sufficient temperature to melt it, that attention was given to the possibilities of the use of same kind of fluxes and slags in modifying the physical and chemical qualities of the resultant weld. Unfortunately, however, while the experience of steel manufacturers and foundrymen were of some assistance, nevertheless their practices could not be altogether employed in welding work.

In welding by the electric arc, the metal is raised to a very high temperature in an extremely small space of time. A different type of flux might, therefore, be necessary to react properly in this short space of time and at this high temperature than would be required with a flux in steel manufacture where the temperature was much lower and the time for reaction much longer.

In welding the parts to be joined the end of the electrode in metallic arc welding is raised almost instantaneously to a temperature so high that the parts to be joined become molten in the immediate vicinity and the end of the electrode vaporized. Oxidation in the presence of air at this high temperature is very rapid. Oxide is a danger to the soundness of the weld, as it may mix with the fused metal and become entrapped and form an inclusion. This oxidation is prevented through a considerable degree by holding a short arc. Proponents for the use of flux and slag coated wires maintain that covering an electrode with some material which shields it from the air until it is on the verge of the arc prevents much of this oxidation and saves electrode material. It must also have such a composition that it will fuse and combine with the

*Paper prepared at the request of the Faraday Society. It will be presented before a joint session of the Faraday Society and Institute of Metals of London in April, 1924. The paper is to be a part of a general discussion on "Fluxes and Slags in Metal Melting and Working." It represents American opinion and practice. The paper is in reality a digest of opinions, proper credit being given to each contributor. However, the author wishes to give especial credit to Major James Caldwell for certain theories in the use of flux covered electrodes.

†Secretary, American Bureau of Welding.

iron oxide to form a light fluid slag which floats on the molten weld metal and does not get entangled with it. It is claimed that the fluid slag protects the hot work of the weld metal from the air and by combining with the oxide present cleans the work surface and promotes the union of the metal projected from the electrode. Some go even as far as to state that the flux covering may be volatilized wholly or partly by the heat of the arc and form a vapor sheath or jacket around the arc, preventing access of air to the iron passing through the arc.

Aside from the above action, the use of flux covered wire is sometimes employed because of the possibility of depositing metal of a more similar composition to the pieces to be joined than would be possible with ordinary bare wire. In passing across the arc the composition of the metal is altered. Carbon, silicon and manganese are, for example, removed, so that there is very little difference in the deposited metal as far as chemical composition is concerned from a pure bare wire or from a manganese mild steel wire. The following analysis of electrode material and deposited metal brings out clearly the above:

ANALYSES OF ELECTRODE—PER CENT OF ADDITIONS

	Carbon	Manganese	Phosphorus	Sulphur	Silicon
Roebling	0.16	0.56	0.032	0.024	0.016
Norway	0.049	0.021	0.025	0.007	0.08
C. R. S.	0.11	0.72	0.097	0.123	0.011
H. R. S.	0.13–0.17	0.50	0.012	0.045	0.011
Toncan	0.10	0.16	0.010	0.046	trace

ANALYSES OF DEPOSITED METAL—PER CENT OF ADDITIONS

	Carbon	Manganese	Phosphorus	Sulphur	Silicon
Roebling	0.05	0.18	0.031	0.036	0.011
Norway	0.05	0.018	0.020	0.072	0.011
C. R. S.	0.05	0.11	0.086	0.072	0.011
H. R. S.	0.14	0.14	0.012	0.039	0.011
Toncan	0.042	0.081	0.019	0.026	0.000

In some instances, such as, for example, welding cast iron or alloy steels, it may be important from either physical or chemical properties that the weld metal shall be substantially equal to the pieces to be joined. One of the methods that may be employed to impart such qualities to the deposited metal is by reaction with the flux material. In this instance the problem is somewhat similar to that successfully solved by a steel man through the use of fluxes and slags.

It is also maintained that in alternating current arc welding the use of flux covered wire will help maintain the arc. The exact theory is not understood, but it is believed that either the surrounding gases help maintain the temperature of the arc during the low part of the cycle or that the surrounding vapor itself possesses some conductivity and therefore helps to maintain the arc during this low part of the low voltage curve.

Fluxes may be applied to the electrode in metallic arc welding either through a light or heavy coating. In the case of a light coating electrodes are dipped in some mixture which on drying

leaves a thin skin of the solids in the mixture. In other cases the electrodes are covered with a material of substantial thickness and solidity. Asbestos yarn is sometimes used in the latter case. It is claimed that the asbestos is a valuable flux in itself, as it fuses and combines with iron oxide into a silicate compound which is easily removed upon solidification. The asbestos yarn also makes possible the addition of other constituents, such as mineral salts or other ingredients necessary to bring about the desired composition and quality of the deposited metal. For example, when welding cast iron, one manufacturer has a coating which carries carbon in such a form and quantity as to combine with the metal in the required manner, leaving the deposited metal, which has a structure typical to cast iron.

Besides chemical composition, the covering must fulfill other requirements, such as mechanical strength sufficient to withstand handling and transportation. It must have a proper melting point, so that it will not fuse too readily and leave the wire bare, or too slowly and form a cup, thereby increasing the length of the arc.

Some of the ingredients of the flux coating may be ferro-silicate, sodium silicate, aluminum silicate, aluminum wire. In a book on electric arc welding by E. Wanamaker and H. R. Pennington, the following analysis of electrode material and deposited metal is given to show the effectiveness of a certain coating to deposit metal high in manganese and carbon content. The author states that the appearance of the weld was perfect, being smooth without gas holes or other imperfections.

Element	Electrode, Per Cent	Deposited Metal, Per Cent
Carbon	0.99	0.71
Phosphorus	0.043	0.061
Sulphur	0.022	0.018
Manganese	10.51	10.19

"The Brinell hardness of the head of the rail was 154, and the average hardness of the deposited metal was 156. Due to the extreme toughness of the metal, much trouble was experienced in pulverizing the deposit for analysis; many tools were broken, and when the sample was finally placed under a steam hammer in an effort to break it up, deep impressions were made in the hammer jaws."

"Another test was conducted to determine the loss of constituents, using electrodes containing alloys in a milder form, and with a very thin coating, such as would permit welding in a vertical or horizontal position. The results are given in the following table:"

Element	Electrode, Per Cent	Deposited Metal, Per Cent
Carbon	0.18	0.15
Manganese	0.50	0.40
Phosphorus	0.012	0.012
Sulphur	0.032	0.032
Silicon	0.140	0.12
Nickel	2.97	2.08

In his book on "Fundamentals of Welding," Mr. J. W. Owens gives the following chemical analyses for coatings and coverings of various electrodes:

CHEMICAL ANALYSES OF ELECTRODE COATINGS AND COVERINGS
Coatings on Ferrous Electrodes of Varying Carbon Content
((The Norfolk Tests)

Sample No.	Calcium Carbonate	Sesqui-Oxide of Iron	Silicate of Soda	Carbon	Iron Oxide	Silicon Dioxide	Aluminum Oxide	Manganese Oxide	Organic Matter	Carbon Content of Electrode
1	45.5	....	36.6	17.9	....	....	....	....	....	0.06
2	20.0	....	68.2	....	....	....	4.72	....	7.08	0.08
3	63.5	23.4	4.3	8.8	....	....	....	....	....	0.11 to 0.19
4	10.78	....	....	....	3.92	77.6	....	....	....	0.13
5	72.82	3.64	....	....	....	22.85	....	0.49	....	0.15
6	35.85	30.0	....	....	....	32.96	....	1.19	....	0.48
7	1.07	6.95	91.98	....	....	....	....	trace	....	0.68

The Scott Anderson Electrode (British) has its surface coated with an aluminum paint and Jones Electrode (British) is nickel plated.

COVERINGS ON LOW CARBON STEEL ELECTRODES
(The Norfolk Tests)

Sample No.	Calcium Carbonate	Sesqui-Oxide of Iron	Silicate of Soda	Asbestos	Loss on Ignition	Undetermined	Carbon Content of Electrode
1	88.25	1.36	0.96	78.5	21.5	0.43	0.91
2	....	....	....	80.0	20.0	....	0.11

Mr. Owens states that the coating is frequently made up with a vehicle having characteristics similar to silicate of soda, to which are added various mineral salts having the desired reducing and fluxing properties. The dry coating must adhere closely and at the same time must be relatively thin. In his report to the Welding Committee of the Emergency Fleet Corporation, Mr. R. E. Wagner of the General Electric Company gives the results of his experiments of electrodes having various coatings and cores in endeavoring to improve the ductility of the deposit. He states that the best results obtained have been with magnesium and boron sub-oxide used as a core or coating on bare low carbon steel electrodes.

Mr. Owens also states that the primary functions of coating are as follows:

"1. To reduce the formation of oxides and nitrides in the metal passing through the arc. This the melting coating accomplishes by partially enclosing the arc, supplying in its composition elements having a high affinity for oxygen and nitrogen, which protect the arc metals and facilitate the holding of a short arc. While ductility in unwelded steel usually is determined by the carbon content, ductility in the deposited metal is determined by the included oxides, nitrides and rate of freezing and cooling.

2. To supply a flux to the molten metal in the crater.

3. To cover the deposited metal as a slag, retarding the formation of scale and slowing the chill.

4. To make electrode manipulation easier for the operator, thereby increasing the sustained speed of welding. One reason for the easier manipulation of the coated electrode is no doubt the stationary location of the arc on the electrode tip in the central crater which the refractory coating assists in forming.

5. To facilitate the use of alloy steels and non-ferrous metals as electrodes, by protecting the elements in passage through the arc.

6. To facilitate the use of alternating current for welding.

"One of the requisites of the slag formed by the fusing of the coating is that it shall not mix with the fluid metal, thus forming slag inclusions. To obviate this it is essential that the slag in liquid form shall not only enclose the arc stream more or less, but shall float to the top of the deposit. The specific gravity of the liquid slag must be low to aid flotation, and at the same time the viscosity should be high. The coefficient of contraction of the slag should be greater than that of the deposited metal, so that when cold it will scale off readily when tapped with a light chisel or hammer, leaving the surface of the metal beneath clean."

"The average coating, due to its fluidity when molten, is hard to manipulate in the horizontal, vertical and overhead positions. However, as most welding of alloy steels is in the flat position, the coating of electrodes for this class of work is entirely practicable."

"Electrodes ruined by the inclusion of gas or having on their surface hydrogen or such acids as nitric and sulphuric, can be made to function properly by applying to their surface an alkaline solution, e. g., a 50 per cent solution of lime or boron sub-oxide, and then subsequently drying."

"Whatever coating is used the object always should be the improvement of otherwise good electrodes and not the salvage of material, which uncoated would be unsuitable for electrodes. All coated or covered electrodes, therefore, should first be tested by welding with them after all traces of the coating or covering have been removed."

"The distinction between the coated and covered electrode is that while the coated electrode is usually dipped in or brushed with a liquid to coat it, the covered electrode is wrapped with a refractory material or otherwise incased in a much heavier covering than that used for coatings. The covered electrode is alleged to possess practically all the advantages of the coated form and in addition has a more completely protected arc. In the wind this should considerably help the operator. However, its refractory covering is a thermal insulator. Covered electrodes designed for overhead welding actually form a minute crucible or enclosure around the arc, thus assisting in the overhead deposition of the metal. The insulating covering can be employed as a means to automatically feed the electrode into a prepared seam. In this case the electrode

is laid directly in the joint after the arc has been established. The covering serves as an insulated support for automatically maintaining the arc and feeding the electrode as the covering fuses."

Mr. R. E. Wagner of the General Electric Company comments as follows on the use of flux in welding and brazing metals:

"In electric arc welding of copper and steel we do not make use of any fluxes whatever. In the brazing of copper and brass, borax is used as a flux. Borax has the chemical formula $Na_4B_4O_7$. The brazing is done with city gas or acetylene. In the welding of cast iron we use borax. Welding of cast iron is done with the acetylene flame. The borax is used, as it causes the impurities in the molten metal to float to the top."

Mr. Speller of the National Tube Company states that his use of flux was limited to brazing of cylinder heads into steel shells. He used borax, which was ground before application, as a flux and found it to be quite satisfactory for the purpose.

Mr. C. J. Holslag of the Electric Arc Cutting & Welding Company states that all slag electrodes are practically 95 per cent silica or silicate, while flux electrodes have very little of this absolutely inert mass and are mostly made up of deoxidizing agents, such as calcium or sodium compounds.

Mr. J. W. Owens of the Norfolk Navy Yard comments further on this subject:

"At the Norfolk Yard we have found that the lime residue obtained from calcium carbide in our acetylene generating plant makes an excellent coating and is used by us when a coating for iron or steel electrodes is desired. The electrode is dipped in a thick solution of the sludge as obtained from the plant and allowed to dry on the electrode. No binder is used."

"With some iron and low carbon steel electrodes a coating improves their welding characteristics and stabilizes the arc at the higher current densities, making it easier to use such currents with an increase in the rate of deposit. We do not find, however, that a coating is necessary on general repair and production work."

In a paper published in the May, 1922, issue of the Journal of the American Welding Society, Dr. P. D. Merica of the International Nickel Company states that in welding monel metal great difficulty was experienced at first to obtain welds that were sound and free from blow holes, shrinking cracks and ductile. These difficulties were attributed to the fact that the metal melted by the arc absorbed sufficient oxygen from surrounding air, making it necessary to redeoxidize it. The agents which were found superior for the purpose are the same as those used in the foundry in casting monel metal, i. e., magnesium, manganese and silicon. Dr. Merica states that these agents are best employed in the form of alloys ground from 50 to 100 mesh and applied to welding rod of bare monel wire as a thin coating. The binder which they use is made up of denatured alcohol, containing one-half pound to the gallon of shellac. The exact composition of the coating powder may

vary within moderately wide limits, the essential thing being to introduce into the weld metal about the amounts of manganese and silicon, and particularly of magnesium, which are generally used for deoxidation in the foundry. Thus they introduce from 0.05 to 0.50 per cent of magnesium, from 0.20 to 1 per cent silicon, and at least 0.20 per cent of manganese; the upper limit of manganese is not important, as an excess is not harmful. The excess of magnesium or silicon, however, would tend to produce dirty or brittle metal respectively.

In welding copper some authors suggest that a flux producing a powerful reducing atmosphere should be used. Borax is also advised. In welding bronze or brass it is recommended by some that the welding rod should be very pure and contain a very small amount of aluminum, which is necessary to deoxidize the welds. A cleaning flux is indispensable and should have the function of dissolving the alumina produced during the oxidizing process. One of the best fluxes is made of powdered salt (NaCl), borax ($Na_2B_4O_7$), and boric acid (H_3BO_3). It is suggested that the filler rod be coated with this flux before welding.

In welding copper to steel, such as in bonding rails, the most successful electrode for either metallic or carbon arc welding is a pure copper wire alloy containing a small percentage (about 0.25 per cent) of a powerful reducing agent. This welding rod is a self-fluxing one. The reducing agent may be silicon. In fusing this alloy in the carbon arc or fusing the alloy as an electrode, the metal flows easily and the reducing agent floats out the oxide on the steel surface and whatever oxide tends to form on the copper surface. It is not necessary to take the ordinary oxide off the rail. At the present stage of development it is necessary to puddle this alloy in order to get a proper fluxing action.

In welding cast iron, particularly if subsequent machining is to be done, the "Welding Encyclopedia" states that good results can be obtained by using a copper aluminum alloy electrode and a suitable flux. It is comparatively difficult to use this alloy electrode, however, due to its low melting temperature and a tendency to drop off the end of the electrode in large globules. Therefore material greater than ¼ in. in thickness must be preheated. An analysis of the electrode shows the presence of 88.48 per cent copper, 3.32 per cent iron, 8.14 per cent aluminum, a trace of zinc and no tin. The flux supplied with the electrode consists of 68.4 per cent NA_2CO_3, 22.6 per cent NH_4CL, and 0.5 per cent NA_2SO_4. Owing to the characteristics of the electrode in the flux a considerable amount of slag is formed, which is rather difficult to remove from the body of the weld during the operation. Another well-known welding company recommends monel metal covered with a flux.

Good flux in the welding to cast iron with the carbon arc can be made of a mixture of equal parts of carbonate of soda and bicarbonate of soda.

Washing soda is the name commonly given to a somewhat impure carbonate of soda, while bicarbonate of soda is ordinary baking soda. There is no necessity that either should be in a chemically pure state. The action of the carbonates is to combine with the oxygen in the slag, releasing the iron and allowing the oxygen to pass off in the form of carbon monoxide or carbon dioxide.

With cast iron the oxide formed is lighter than the melted metal and does not flow at quite so low a temperature. The slag which forms on the surface of the iron, therefore, tends to hold the melted metal into place. Scaling powder should be added by dipping the rod into the powder only when the metal does not flow well, and no more should be used than is necessary.

When using a flux in welding cast iron, it will be noticed that as soon as a small portion of it is put on the melted iron the surface of the metal becomes clear and mirror-like, thus making a good weld possible.

Mr. J. C. Lincoln of the Lincoln Electric Company, in commenting upon his experience in welding non-ferrous metals with the carbon arc, states that in melting copper end rings and rotor rods he finds the addition of brass scrap advantageous. He states the reason for this is probably that the brass scrap furnishes a conducting vapor in the arc more readily than copper. In order to get rid of the blow holes in electric welding of copper it is necessary to have a strongly reducing atmosphere, which is furnished by a short arc and a carbon pencil. In cases where a long arc is necessary or where there is a possibility of drawing a long arc it is advisable to use some material which will deoxidize copper. Small amounts of aluminum or silicon are effective in doing this.

In a paper before the American Welding Society, published in the January, 1923, issue of its Journal, Mr. O. H. Eschholz of the Westinghouse Electric & Manufacturing Company states that by the use of a special coated nickel steel electrode it is possible to secure unusual depth of penetration and great speed in metal deposition.

FLUXES IN GAS WELDING

Fluxes are sometimes used in oxy-acetylene welding in the form of a powder or incorporated in the welding rod itself. The composition differs for different metals that are welded. In welding cast iron a flux is used for breaking up the oxide of iron which forms as a slag on the surface. Mr. S. W. Miller in his book on oxy-acetylene welding recommends that the flux be a mixture of equal parts of carbonate of soda and bicarbonate of soda. He states that a good way to prepare a flux is to grind the washing (carbonate of soda) and baking (bicarbonate of soda) sodas together in an ordinary meat grinder, passing the material through the hopper two or three times in order to secure a thorough mixture. The action of the carbonates is to combine with the oxygen in the

slag, releasing the iron and allowing the oxygen to pass off in the form of carbon monoxide or carbon dioxide.

It will be noticed in the use of a cast iron flux that as soon as a small portion of it is put on the melted iron the surface of the metal becomes clear and mirror-like and that under such conditions the union of the metal in the work with that of the welding rod is easily made.

The same type of flux is sometimes used in welding steel (although successful welds with proper care may be made without its use).

In welding copper, phosphorus is sometimes incorporated in the welding rod to eliminate occluded gases and blow holes.

In welding copper alloys Mr. Miller states that ordinary borax gives very good results. To prepare the borax for use it should be melted and then allowed to cool, after which it is powdered, because in its original condition the borax does not lie quietly in the weld but foams up and a great deal of it is wasted.

Great care must be taken in welding aluminum, even with the use of a flux. When aluminum is melted it oxidizes freely, and as the outside of the slag is heavier than the melted metal and melts at a much higher temperature, the tendency is for it to become mixed with the molten metal and weaken the weld. To decompose the oxide requires a very chemically active flux. However, with the use of flux difficulty is experienced after a period of time because of the destructive action of the flux on the aluminum itself for some distance from the weld. It is very difficult to reweld a section composed of aluminum which has been previously welded with the use of a flux. In some instances, therefore, it may not be advisable to use it, particularly in the repair of broken parts. In welding of sheet aluminum, of course, the use of a flux is desirable. A flux which has been developed in France by the Autogenous Welding Association has a composition shown in the following table:

COMPOSITION OF FLUX FOR WELDING ALUMINUM

Ingredients	Per Cent
Lithium chloride	15
Potassium chloride	45
Sodium chloride	30
Potassium fluoride	7
Potassium bisulphate	3

In some cases instructions are issued that after welding is done the piece must be thoroughly washed off with boiling water to remove the remnants of the flux. The flux given in the table above gives a bright red color to the flame characteristics of lithium salts.

In his book on Oxy-Acetylene Welding, Mr. S. W. Miller gives the following table for fluxes to be used in welding aluminum. He states that the melting point of the flux must be somewhat below

that of the metal, so that the former will melt and flux away the oxide just before the metal begins to flow. In actual use the flux powder is moistened down with alcohol. Otherwise it will be scattered by the draft from the blowpipe; in its dry form, too, the powder is very hygroscopic and liable to deteriorate, due to absorption of moisture. Another method employs the flux in the form of the core to the feeding stock, which is made hollow for the purpose. This, as a rule, can only be used as supplementary to the flux pasted on the joint.

FLUXES FOR WELDING ALUMINUM COMPILED BY S. W. MILLER

Sodium Chloride, Per Cent	Potassium Chloride, Per Cent	Lithium Chloride, Per Cent	Sodium Fluoride, Per Cent	Potassium Fluoride, Per Cent	Sodium Bisulphate Per Cent	Potassium Bisulphate Per Cent	Sodium Sulphate, Per Cent	Potassium Sulphate, Per Cent	Cryolite (Aluminum-Sodium), Fluoride), Per Cent
30.0	45.0	15.0	....	7	3	....		....	....
....	33.4	33.3	33.3	....	....	....	....	....	....
12.5	62.7	20.8	....	....	....	4	....	....	....
16.0	79.0	....	....	....	....	....	....	5	....
17.0	83.0	....	....	....	....	....	....	....	....
6.5	56.0	23.5	....	....	....	....	4	....	10

Mr. Miller further states that good welds can be made without the use of a flux by puddling the weld with a rod made of soft steel about 3/16 in. in diameter. In his opinion there are two points to be considered in connection with the use of flux. First, all aluminum castings are more or less porous, due to the presence of oxide, and therefore the weld need not be any better than the casting. Second, even by the use of a flux it is not possible to make a perfectly sound weld, although under the best conditions it is somewhat freer from porosity than when made without a flux. He therefore concludes that the arguments against the use of a flux carry more weight than those in favor of it.

In his book on "Fundamentals of Welding," Mr. J. W. Owens states: "In gas welding the primary function of a flux is to prevent the formation of oxides and nitrides and to eliminate those which have been formed. The mantle of the gas burner protects the molten metal from oxidation and if the weld is properly made the necessity for flux will be minimized and even entirely avoided. Flux generally is used in the form of a powder, into which the rod is dipped. It may be dissolved in alcohol and the end of the rod dipped in the liquid, or it may be brushed on the joint previous to welding. It may also be added to the composition of the rod itself or encased in a thin metal tube, thus permitting it to be applied uniformly over the whole joint to be welded. For overhead welding this latter method of application is advantageous.

Mr. Owens states that the object of a flux in the case of cast iron is to break up at the fusion temperature the oxide into its component parts. Mr. Owens gives the following table of chemical analysis of fluxes for gas welding:

states that the melting point of the flux must be somewhat below

CHEMICAL ANALYSES OF FLUXES FOR GAS WELDING

Commercial Fluxes for Cast Iron

Sample No.	Sodium Carbonate	Sodium Bicarbonate	Sodium Nitrate	Borax
1	50.0	50.0	....	...
2	26.6	...	50.00	23.4

Commercial Fluxes for Copper and Its Alloys

Sample No.	Borax	Boric Acid	Sodium Nitrate
1	....	100.00	....
2	76.76	23.24	....
3	....	60.00	40.00
4	....	73.60	26.4

Aluminum Fluxes

Sample Nos.	1	2	3	4	5	6	7	8	10	11	12	13
Sodium Chloride	30.0	30.0	.....	12.5	16.0	17.0	6.5	86.0	16.36	90.0	14.5	86.0
Potassium Chloride	45.0	45.0	33.4	62.7	79.0	83.0	56.0	.....	.....	.....	.....	.....
Lithium Chloride	15.0	15.0	33.3	20.8	.....	.....	23.5	.....	.....	.....	.....	.....
Sodium Fluoride	.....	.....	33.3	.....	.....	.....	.....	.....	.....	.....	.....	.....
Potassium Fluoride	7.0	7.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Sodium Bisulphate	.....	3.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Potassium Bisulphate	3.0	.....	.....	4.0	.....	.....	.....	.....	.....	.....	.....	.....
Sodium Sulphate	.....	.....	.....	....	.....	.....	4.0	14.0	3.63	9.0	70.0	14.0
Potassium Sulphate	.....	.....	.....	....	5.0	.....	.....	.....	.....	.....	.....	.....
Aluminum Sodium Fluoride	.....	.....	.....	.....	.....	.....	10.0	.....	.....	.....	.....	.....
Borax	.....	.....	.....	.....	.....	.....	.....	.....	70.0	.....	11.7	.....
Sodium Carbonate	.....	.....	.....	.....	.....	.....	.....	.....	10.01	.....	3.5	.....

Sample No. 1 devised in France by the Autogenous Welding Association; Nos. 2 to 7 inclusive from "Oxy-Acetylene Welding," by S. W. Miller; and Nos. 8 to 13 inclusive are commercial samples from the Norfolk Navy Yard. Tests.

FLUXES IN RESISTANCE WELDING

In Progress Report No. 1 of the Committee on Welded Rail Joints of the American Bureau of Welding, Mr. H. F. A. Kleinschmidt of the Lorain Steel Company comments on the use of flux in making resistance bar welded rail joints in street rails as follows:

"Borax glass. Previous to 1908 no flux was used. In the winter of 1907-8 experimental tests were made to determine the value of the flux. Numerous tests were made on various kinds of rail by welding with and without the flux and in every case the joints welded with the flux were of higher tensile strength. Final tests were made by selecting 26 rails, Section 129-403, and cutting from each rail four short pieces of rails for the test joints. One pair of rails was then welded without the flux and the other pair with the flux. Special care was taken that the two sets of joints should be alike in every particular except in regard to the use of the flux. The result was as follows: Average ultimate tensile strength of 26 joints welded without the flux, 287,790 lbs.; average ultimate tensile strength of 26 joints welded with the flux, 335,990 lbs. Of the joints welded without the flux the rails broke in 21 cases, the lowest being 163,450 lbs. and the highest 314,050 lbs., and the rails broke through the bars in five cases, the lowest being 264,000 lbs. and the highest 331,370 lbs. Of the joints welded with the flux the rails broke in fifteen cases, the lowest being 328,940 lbs. and the highest being 367,370 lbs., and the bars broke in eleven cases, lowest 310,340 lbs.

analysis of fluxes for gas welding:

and the highest 347,100 lbs. Only three of the joints welded without the flux were of a higher tensile strength than the lowest of the ones welded with a flux."

In making resistance butt welded joints in street rails, Mr. Kleinschmidt states that after the clamp has been fastened to the rails and the molds set around the rail ends, the terminals of the generator are fastened to the two cross-heads of the clamp and the generator is started. The flux of molten borax is poured into the mold after it is set and just prior to the application of the electric current.

Conclusion:

The knowledge of the use of fluxes in welding is in a very unsatisfactory state. Practices are based largely on the results of practical experience where the use of flux has been found to give results which have proven satisfactory in service. Very little scientific effort has been made to analyze the functions of the flux, their best composition, their best methods of application, and the results attained from their use. It is believed by some that the use of flux will in some instances give better results than welding without its use. Test results are needed to substantiate these opinions.

Welding Manifolds, Exhaust Tubes and Trunks

Z. T. DAVIS

Little does the average motorist realize the thought and attention that has been given to inconspicuous parts of his motor car, to the end that possible sources of trouble may be avoided. Oxy-acetylene welding has been very frequently chosen as the one acceptable method of joining metal, when screwed connections and riveted joints proved unreliable in practice or theory. Welding assures that permanent tightness and strength that is desired.

Three quite different automobile parts—water manifolds, exhaust tubes and trunks—illustrate this point. They are manufactured by a concern specializing in metal stampings and fabricated units for the automotive industry. In each instance the process has met all demands, involving the essentials of tightness, durability and economical manufacture.

For several years this plant has produced much welded sheet metal, although its principal line is stampings and pressed metal products. Having built up a very excellent welding organization, and having extensive oxy-acetylene facilities, it is especially well equipped to handle the fabrication of parts such as the above which require especially strong or tight seams, and which may be used in some unit assembled by another manufacturer. A muffler tube illustrated below is a good example.

These are made from 0.035-in. sheet, are 12½ in. long and of

3 in- diameter. When forming the cylinder the edges are flanged about 1/16 in. This facilitates rapid welding and produces a strong, tight joint. A flange weld on this gage metal requires no welding rod except where a poor section of sheet may be encountered. An average of 600 a day per man is attained without the assistance of a helper.

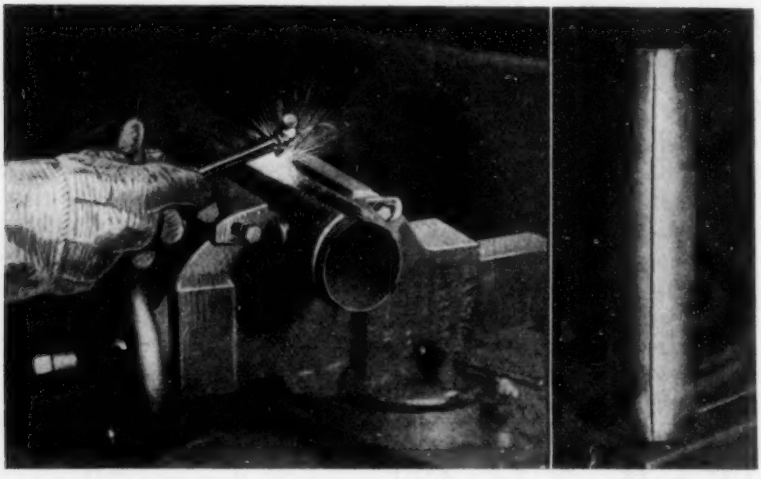


Fig. 1—Utilizing a Vise in Welding Muffler Tubes

A particularly handy jig used in welding the tube is shown in operation. An ordinary vise is equipped with wheels so the jaws can be opened and closed quickly. Pieces of pipe, cut lengthwise and about the same diameter as the tubes, are welded to each jaw. In operation, the workman has only to place a tube in the vise and turn the wheel slightly to bring the flanged edges tightly together for welding.

MANIFOLDS

The manifolds for automobile engine cooling systems are fabricated from brass flanges brazed to 0.049-in. gage steel tubing. The first production operation consists in brazing the brass flanges to the legs or T branches which are set in holders by a helper. One operator can turn out 500 of these parts a day. Then two of these legs and another flange for the end of the manifold are set up in another jig. The whole jig can be rotated and the part holding the manifold can be turned through a vertical circle. This allows the operator to reach each point to be brazed without changing his position. With these jigs and the assistance of a helper one operator brazes three joints (a brass flange to one end of the tube and the two "T" connections mentioned above) and averages 225 complete manifolds a day. Joints are ground flush and polished and then the whole unit is nickel-plated.

TRUNKS

Trunks placed on many recent models of pleasure cars have created a market for several types. They must be manufactured at a comparatively low cost but stand the abuse of road service. In many cases, cost prevents the use of a fabric or veneer trunk of the usual construction, but a metal trunk meets all the require-

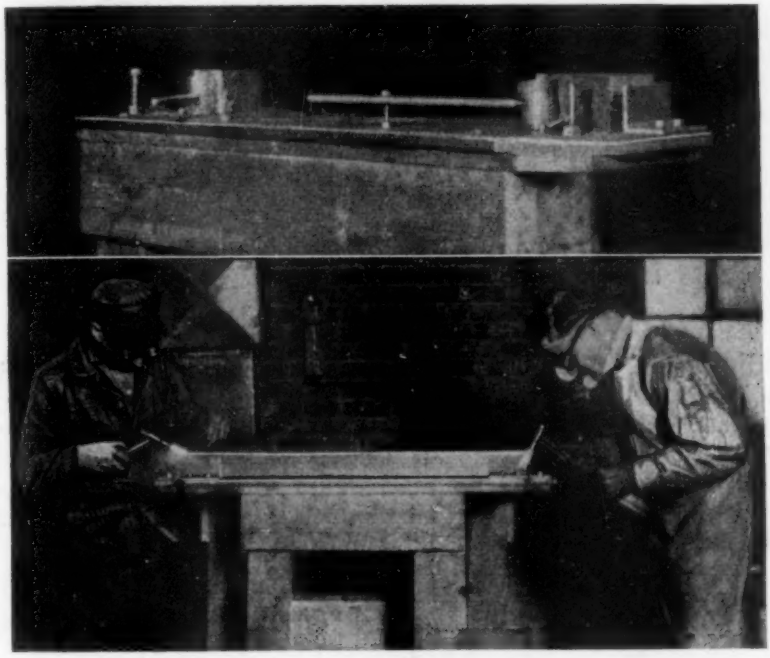


Fig. 2—Jig Used in Welding the Two Top Corners of a Trunk.

ments of lightness, economy and strength. Strength is satisfactorily obtained by oxy-acetylene welding, especially in the corners, points subject to the greatest strains.

Trunks made in this shop are fabricated from 8- and 20-gage glazed steel. Eight corners are welded on trunk and cover all told, involving about 10 linear inches of welding. Where the sides butt together, a regular corner weld is made. The edges do not meet at the corners on account of a V having been taken out in order to turn the metal. Here a small additional piece of metal is inserted and welded in, forming a strong reinforcement. On this work a jig is used only in welding the two corners on the top. Production averages 17 welds an hour. The welds are file finished and the whole job is black enameled.

It is worth while to consider the circumstances existing in this shop because of the ease and dispatch with which an entirely new line, such as that of these trunks, can be handled when demand

presents itself. The same oxy-acetylene equipment and personnel employed on hundreds of other sheet metal products was transferred to production welding on the trunks without the slightest

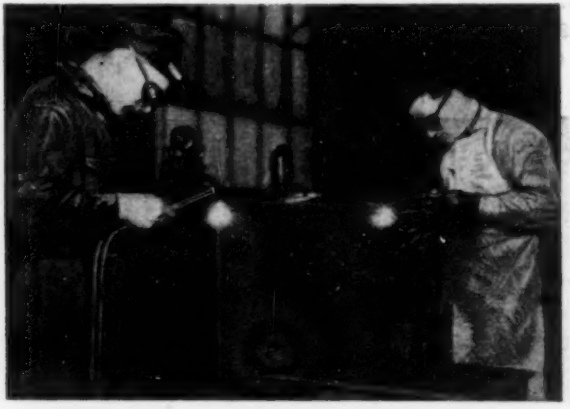


Fig. 3—Completing the Trunk

readjustment. Knowing that such things can be accomplished, a plant having oxy-acetylene facilities can go into widely diverse fields and solicit contracts for sheet metal work which otherwise could not be profitably handled. One of the strongest arguments in favor of welded construction in the automotive field is that it permanently eliminates all the objectionable features of other joining methods. One can't lose a bolt from a welded joint!

CURRENT WELDING LITERATURE

Applications of Arc Welding to Ship Construction, Part 5, E. H. Ewertz, Marine Engineering, Dec., 1923, Vol. 28, pp. 774-778. Tables showing time required for various types of electric welded joints as compared with riveted construction.

Applications of Arc Welding to Ship Construction, Part 6, E. H. Ewertz, Marine Engineering, Jan., 1924, Vol. 29, pp. 47-54. Results of tests to determine strength of welded joints. Attitude of classification societies toward application of electric welding.

Applications of Arc Welding to Ship Construction, Part 7, E. H. Ewertz, Marine Engineering, Feb., 1924, Vol. 29, pp. 114-121. Lloyd's rules and regulations for the application of electric arc welding to ship construction. Corrosion. Bibliography.

Arc Welding Cast Iron Without Preheating, C. J. Holslag, Machinery, New York, Jan., 1924, Vol. 30, p. 392. Use of nickel as an electrode in welding, development of the process, nickel alloy electrodes.

Arc Welding Reduces Scrap Pile, L. J. Mck. Yardley, Elect. News, Jan. 15, 1924, Vol. 33, pp. 54-6. This electrode process reclaims tremendous quantities of machinery every year. Portable and stationary equipment available for all purposes, methods and costs on a big cast iron job.

Autogenous Welding, E. Beinet, Rev. Gen. Elect., Dec. 22, 1923, Vol. 14, pp. 16-20. International congress on acetylene, autogenous welding and related industries.

Electric Welding of Aluminum, Canadian Foundryman, Jan., 1924, Vol. 15, p. 24. Preheating, light castings.

Fabricating Steel Cylinder Heads by the Oxy-Acetylene Torch, American Machinist, Feb., 1924.

Fusion Welding, Possibilities and Limitations Of, Part 2, Railway Age, Dec. 29, 1923, Vol. 75, pp. 1201-4. Oxy-acetylene cutting, resistance welding, thermit welding.

How to Make a Machinable Cast Iron Weld, T. E. Bransome, Inco, Vol. 4, fourth quarter 1923, pp. 21-22. Resistance grids, chemical industry molds, nickel chromium cast iron.

Jobs for Men and Men for Jobs, Grady Triplet, Welding Engineer, March, 1924, Vol. 19, pp. 19-21.

Machine Torch Cutting in the Forge Shop, Fred E. Rogers, Acetylene Journal, March, 1924, Vol. 25, pp. 440-441.

Manufacturing Welded Steel Bedroom Furniture, Acetylene Journal, March, 1924, Vol. 25, pp. 429-432. Extensive production of steel furniture at Simmon's Company's plant at Kenosha, Wis. Importance of the oxy-acetylene process for welding and brazing.

Oxy-Acetylene Welding and Cutting in Railroad Car Shops, Acetylene Journal, March, 1924, Vol. 25, pp. 433-436. The oxy-acetylene installation, welding and cutting in production, reclamation, welding and cutting, repairing and reconditioning used cars and parts, central welding shop, cutting for demolition, oxy-acetylene blow-pipe, heating application.

Production Brazing, B. Heyman, Welding Engineer, March, 1924, Vol. 9, pp. 19-21. Standardized conditions of operation are necessary for best results. Provision for comfort of operators.

Rules for Safe Handling of Cylinders, Welding Engineer, March, 1924, Vol. 9, p. 32. Oxygen, acetylene, hydrogen, etc.

Standardization of Welding Cost Finding Methods, Canadian Manufacturer, Feb., 1924. Illustrating the value of standardization of practice in applying the welding or cutting process.

Tanks, Building of Large Field Tanks Treated by Oxy-Acetylene Expert, E. Moses, Oil and Gas Journal, Jan. 10, 1924, Vol. 25, pp. 36, 90 and 92. Examples in field, problems are met, exhaustive tests.

Use of City Gas for Cutting Steel, J. H. Gumz, Western Machinery World, March, 1924, Vol. 15, pp. 85-87.

Waterwheel Buckets Built Up by Welding, Power, March 25, 1924, Vol. 59, pp. 397, 398.

Welding All Steel Automobile Bodies, Jos. W. Meadowcroft, Acetylene Journal, March, 1924, Vol. 25, pp. 443-444.

Welding Locomotive Tires, Railway and Locomotive Engineering, Jan., 1924, Vol. 37, pp. 21-3. Details of an elaborate investigation as to the effect of building up flanges.

Welding Monel Metal and Nickel, Welding Engineer, March, 1924, Vol. 9, pp. 19-21. General features of fusion welding (arc or oxy-acetylene), oxy-acetylene welding, carbon arc welding, metallic arc welding, which method to use, welding rod sizes, spot welding monel metal, butt welding monel metal, seam welding monel metal, monel metal rods for welding cast iron.

Welding Standardization in Locomotive Shops, James S. Heaton, Railway Mechanical Engineer, March, 1924.

Welding Stellite with the Oxy-Acetylene Torch, Herman Ullmert, Welding Engineer, March, 1924, Vol. 9, pp. 19-21. Flame, temperature, type of welds, welding operation.

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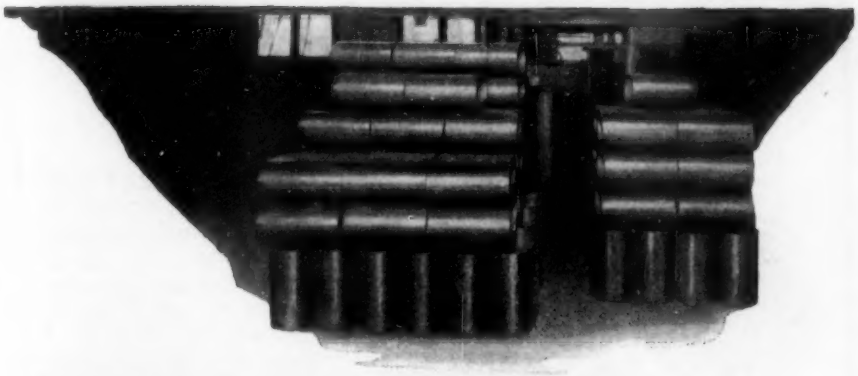

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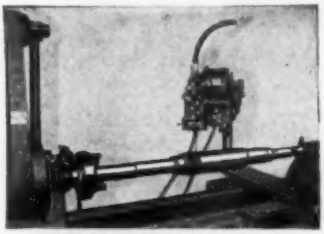

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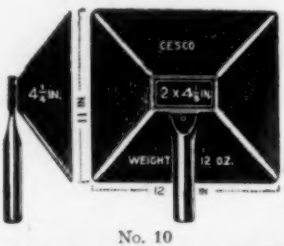

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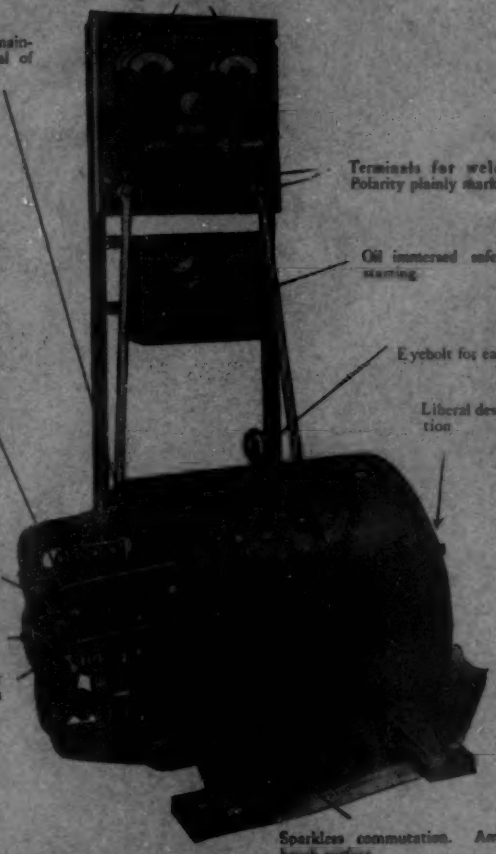
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